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Scrapping the Battleships

THE account of the scrapping of the battleships condemned by the Disarmament Conference, published in this issue, is of interest as a description of the methods followed in solving an unusual and novel engineering problem.

To the shipbuilders who constructed these vessels, however, and to the naval officers and crews who manned them it is not pleasant reading.

The building of these ships exemplified the attainment, by a large body of American engineers and mechanics, of the highest degree of constructive skill, a skill only to be possessed as the result of long years of patient toil and the very highest type of specialized scientific investigation and engineering development. Their successful handling demanded and had resulted in the attainment, by the officers and crews who manned them, of the very highest degree of professional naval skill and efficiency.

One may well ask, what is to be the end of it all? What is to become of the men who built and manned these vessels and the great and efficient organizations which made both the building and the manning possible?

While there may be some question as to the most efficient type of naval ship, there is no evidence whatever to show that surface fleets will not be the backbone of defense and offence in future wars, or that they can be summarily done away with.

Is there not some way by which it can be brought home to the people of this country, that they must have a real and not a freak navy and that the organizations which built up our fleet in the past must at any cost be preserved, as among the country's most vital and essential possessions?

The Naval Architects' Meeting

IN common with all scientific societies, it is through its published Transactions that the Society of Naval Architects and Marine Engineers is best and most broadly known to the engineering public. While these transactions contain, each year, papers of value to the profession, we do not believe that ever in its history has a meeting of the society brought forth papers of a higher average of value than those read at the recent annual meeting in New York. Not only were this year's paper all of more than ordinary interest, but the discussion developed by them was unusually valuable, being participated in by some of our best known naval architects and engineers, men whose recognized and proved ability gains for them an eager hearing in any professional gathering and whose comments invariably add to the value of any paper which they may discuss. We hesitate in naming any particular paper, all furnished food for reflection and contained information of professional value along particular lines.

From the theoretical or scientific standpoint, Admiral Taylor's paper on the comparison of model propeller experiments is of outstanding importance. Much investigation of this nature has been carried on in the various experimental tanks, but the methods pursued and the sizes of model screws employed have varied widely. So far as we are aware, this is the first comprehensive attempt which has been made to compare the various results obtained and check them against one another. To the student of propeller action and performance, the facts brought out by this comparison cannot fail to give very great satisfaction. There has long been doubt in the minds of many engineers as to the accuracy of data obtained by the use of the smaller sizes of model propellers and the fact that Dr. Schaffran's results, deduced from the performance of 4¾-inch models, are found to check closely with those of Froude, Durand and Taylor is of the utmost importance. In effect, it places the whole subject of model propeller experiments on a much more satisfactory basis and will go far in increasing the confidence with which model screw data may be considered and made use of.

Turning to the practical side of ship construction, Mr. Williams' paper on refrigeration is in a class by itself. Very little has appeared in the Transactions relative to refrigeration on shipboard and the comprehensive manner in which the subject is handled as well as the additional light thrown upon it in the discussion is likely, as Capt. Gatewood well remarked, to make the paper a basis for future standard practice.

As an illustration of the direct application of scientific methods to the attainment of eminently practical results, Mr. Jefferson's paper on fuel conservation is worthy of particular mention. We have often had occasion to draw attention to the valuable work being carried on by certain departments of the Fleet Corporation. Possibly the most far reaching in its effects is the introduction of standards of engineering efficiency aboard ship, a work being done under Mr. Jefferson's immediate supervision. The results obtained are obvious and it is a great satisfaction to know that the record of work so well done and of such immediate value has been made permanent and is available for general use.

The papers mentioned treat of three distinct phases of the naval architect's or marine engineer's work and serve as an illustration of the wide range of subjects covered by this year's meeting. All of the papers read appeared to arouse more than ordinary interest and were discussed at length. Altogether, the meeting was one of the most satisfactory the society has held in recent years.

Condenser Tubes

During the war the necessity of vast quantity production in the manufacture of what are generally known as engineering materials brought about a certain lowering of standards, under the circumstances entirely legitimate, but the correction and elimination of which will require a considerable period of time. Unfortunately there occurred, coincident with the requirement of quantity production of material, in certain cases, almost revolutionary changes in the conditions surrounding its use, and to this fact, we believe, may be attributed many of the doubts still lingering in the minds of engineers as to the quality of certain materials as at present produced.

The quality of condenser tubes is a case in point. For some reason, just what it is being in more or less doubt and a most prolific subject for discussion among engineers, surface condensers appear to have given an undue and abnormal amount of trouble during the past five or six years. Inquiry among superintending engineers as to the average life of condenser tubes has elicited some interesting information. It appears that the yearly tube replacement necessary to keep condensers in good working condition on shipboard varies roughly from 25 to 33 percent, corresponding to an efficient tube life of from 3 to 4 years, while in some instances tubes have had to be replaced after a few weeks of service. We have not at hand any reliable information as to the average life of condenser tubes previous to the war but it was certainly measured in years and not in weeks or months. Under the less strenuous and exacting conditions imposed by the older and more "easy going" types of marine engines, a tube life of 15 or 20 years was by no means uncommon.

The unsatisfactory results obtained in many instances with tubes manufactured since the war have been very generally attributed by ship operators to a lowering of the standard of quality resulting from careless mixing in the making of the metal and the frequent presence of free copper in defective tubes appears, at first sight, to sustain this point of view. A little consideration of the process of manufacturing tube metal makes it clear, however, that the presence of free copper or zinc in the finished tube is very improbable, if not quite impossible. It is customary to place in the crucible a certain proportion of new scrap, of the same composition as that desired, and when this is melted the copper necessary to produce the required amount of metal is added. Finally when the copper is fused, zinc is added and after thorough stirring the resultant mixture is poured into cored iron molds. Now the melting point of zinc is something over 400 degrees C. and that of copper nearly 1,200 degrees C. The melting point of a 70-30 mixture of copper and zinc is about 930 degrees C. Furthermore, owing to the chilling effect of the iron mold, the pouring temperature is kept above 1,000 degrees C. Under these conditions it appears highly improbable, to say the least, that any free copper or zinc should find its way into the mold or appear in the finished tube. When particles or "plugs" of copper are found in a tube which has failed it seems pretty certain that they have been deposited as the result of corrosive action and did not exist, in the free state, when the tube was first placed in the condenser.

It appears, moreover, from certain experiments conducted in Great Britain, to be possible to draw a tube of average 70-30 composition from metal made without the use of scrap and *without* stirring or pouring; the tube containing zinc which varied in amount from 10 to over 40 percent, the proportions of zinc and copper varying continuously along the tube. Such tubes did not contain irregularly melted lumps of copper. Furthermore, it must be remembered that, if copper lumps occurred in the shell from which the tube was drawn, they would appear in the latter as long fibers and not in the form of the plugs often found in corroded tubes.

The presence of any considerable amount of impurities in the tube metal would, undoubtedly, under certain conditions, lead to rapid deterioration but analysis shows that they very rarely exist in sufficient quantity to have a destructive effect and furthermore, samples taken from defective and good tubes in the same condenser will show identical proportions of copper, zinc and other minor constituents. It would seem, then, that one must search elsewhere than through the manufacturing processes to find the principal causes of failure in modern condenser tubes.

The very general adoption of turbine machinery and the accompanying necessity of high vacua and high temperatures have greatly increased the severity of the conditions under which condensers operate. The principal change from former practice has been an increase in the speed of the circulating water in passing through the tubes. Thus the mechanical effect of particles of solid matter carried by the water is not only greatly magnified but the rapidity of such chemical action as may take place between the water and the tube surfaces is also increased. Finally, the greater speed of the water appears to result in the liberation of such air as is entrained in it and the setting up of an action somewhat similar in nature to that of "water hammer" in steam pipes.

At first glance it would appear that such actions as have been described would have an equal effect on all the tubes, while, as a matter of fact, this is not what happens. Tubes of apparently identical composition fail not only in different parts of the same condenser, but at various spots along their own length. This would indicate defects in the individual tubes that failed were it not for the fact that failure often reoccurs in the same location while other tubes are not affected. An explanation of this phenomenon may be found in the fact that while we may know the *average* speed of the circulating water through the tubes, we do not know the *actual* speed in any particular tube and a study of the arrangement of the average condenser shows quite clearly that there must be a considerable variation in velocity between the differently located tubes and a corresponding difference in the intensity of the erosive or chemical action taking place in them.

To the preceding conditions, arising largely from the increased severity of service placed upon the condenser by the requirements of modern machinery, may be laid a large proportion of the difficulties experienced with condensers.

Longer life of tubes may come as a result of improved material or changes in condenser design; both will undoubtedly contribute to an eventual successful solution of the problem. The production of an equal rate of flow through all the tubes and the reduction of eddies and irregularities at the entrance of the tubes will undoubtedly go far toward preventing a concentration of corrosive action at any particular point. The use of nipples, similar to the ferrules sometimes fitted in boiler tubes under forced draft, in the front end of the tubes, which is reported to produce very satisfactory results, is a step in this direction.

A committee of the Institute of Metals in Great Britain has made an exhaustive study of the corrosion of condenser tubes and has conducted numerous experiments along some of the lines upon which we have briefly touched. In a paper read before the North-East Coast Institution of Engineers and Shipbuilders, something over a year ago, a detailed account of the work of this committee was given. The following summary, bearing upon the air-water action in condenser tubes, as demonstrated by the committee's experiments is of particular interest:

(1) The presence of entangled air in a stream of sea water greatly increases the power of corrosion of that stream on 70 : 30 brass and a variety of copper alloys.

(2) If the temperature of the water be raised from atmospheric to 40 degrees C., the rate of corrosion of copper and some of its alloys, such as 80 : 20 copper-nickel, is increased; the rate of corrosion of 70 : 30 brass is decreased.

(3) The higher the water-speed up to 25 feet per second the greater the corrosion.

(4) The volume and state of sub-division of the air affect the rate of corrosion.

(5) Electrolytic protection of the ordinary type has but a very limited effect in preventing the corrosion. Protection is effective only near the ends of the tubes, and sometimes fails even at these.

(6) The critical period in the life of a tube is its early life when there is little or no sea scale on the tube: at this stage tubes are very susceptible to attack by aerated sea water.

(7) Certain types of sea scale may be very resistant to erosion by air-water jet, and, consequently protect the tube. The scales on old tubes that have stood up well in practice may be hardly noticeably attacked in conditions in which a new tube would be severely corroded.

(8) To some extent the production of scales resistant to rapid air-water attack can be carried out artificially.

(9) Such scales should be useful in tiding the tube over its early critical period and preventing rapid failure. In due course such scale may or may not break down owing to chemical changes; in the former case the tube may eventually fail by local pitting or general thinning.

(10) Certain scales even when very thin, *i.e.*, only a few hundredths of a millimeter thick, may be highly protective.

The indicated tendency to rapid corrosion, when the tube is new and bright, and the protective properties of certain classes of scale, are of particular value as pointing to possible methods of protecting the tubes when new.

Aside from the causes of tube failure which have been enumerated, there is also present in most condensers a certain amount of direct electrolytic action. This, however, may be neutralized by the use of zinc protective plates. Another occasional source of trouble arises from the grounding of the ship's electric system through the condenser or its connections. Particularly is this true of ships wired on the one-wire system. We know of at least one large ship where the most serious damage was done by the grounding of the generators through the condenser and copper circulating water pipes. Too much care cannot be taken when the one-wire system is used to insulate the base of the generators and their condenser connection and to thoroughly ground them on the steel hull structure.

Block Coefficient

WHILE, from a strictly scientific point of view, the block coefficient of displacement is not an ideal measure of the form of vessels and for purposes of comparison is inferior to the cylindrical or prismatic coefficient, it is, nevertheless, a useful factor in the approximate appraisal of the character of a commercial vessel of any given type. Particularly is this true for cargo ships of relatively low speed.

The question of the proper degree of fullness in cargo vessels has been a prolific subject of discussion among naval architects and ship operators for many years and a vast amount of experimental work has been done in the various model tanks to determine the effect of varying degrees of fullness upon the still water resistance and speed of this class of ships.

Like many other of the problems which the naval architect has to solve, the determination of the most satisfactory block coefficient is closely involved with so many different considerations that the solution is, of necessity, a compromise between more or less conflicting requirements. In the last analysis, the problem is of a commercial rather than an engineering nature, its solution resting upon the determination of the most efficient type of performance for a ship on a given trade route as indicated by the closely interrelated qualities of speed, fuel consumption and carrying capacity. In certain trades, the type of vessel is obviously indicated—a slow, full bodied ship or a faster vessel of finer lines being clearly required. On the other hand, in many, if not in most, services the exact type to give the most efficient and economical results is not so easily determined.

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Using tank results and trial conditions alone as a basis of comparison, there seems to be a good deal to be said in favor of the full lined vessel. The extra power required by the added fullness is not usually excessive (we are speaking, of course, of speeds of around 10 knots) and certainly the increase of block coefficient is the cheapest way, other factors remaining constant, to obtain deadweight capacity.

Immediately we turn to service conditions, however, the advantage lies very largely with the finer lined vessel. Under ordinary sea conditions with an average amount of rough weather, the excessively full ship fails altogether to maintain her expected speed or does so at the expense of an excessive amount of fuel. In trades where large deadweight capacity is essential and speed or time of cargo delivery is of secondary importance, the large block coefficient may be employed to advantage, but it is an advantage which may easily be pushed too far and the apparent gain found to be largely a "paper" one and more than offset by loss of speed and abnormal fuel bills under ordinary service conditions.

For most services cubic capacity appears more valuable than deadweight; in other words, there is a larger proportion of measurement than of deadweight cargoes. This being the case, there is little reason for building ships with excessive block coefficients, as it is usually possible to fine a ship's lines to a quite considerable extent without materially reducing the cubic capacity. On the other hand, every ton of displacement removed by fining is a direct reduction in deadweight, for while fullness means added weight of hull, the change in displacement resulting from a change in block coefficient is roughly four times the corresponding increase or decrease in hull weight.

It seems to be pretty generally conceded that for ocean going vessels an excessive block coefficient is not desirable. There are certain services where full advantage may be taken of the weight carrying possibilities of high block coefficients, notably in the large ore carriers of the Great Lakes. But these vessels operate in smooth water, practically never experiencing anything approaching the conditions of sea accompanying a North Atlantic gale. Moreover, they are of great length for their speed which tends to reduce the residuary resistance, and also makes it possible to have relatively fine ends, particularly aft, while still holding to a maximum coefficient of fineness for the total displacement.

To the naval architect, the block coefficient is largely a relative matter. Once the owner has determined the service speed, it is for the former to appraise the various elements of the design and adjust them to produce the desired result in the most economical manner, having in view both the initial and operating costs. Too often the latter appear to be forgotten and a too close adherence to the saying that "A bird in the hand is worth two in the bush" has made poor investments out of what otherwise might have been satisfactory and profitable vessels.

The tendency of the times appears to be definitely towards the construction of finer and faster cargo vessels, particularly as more and more of these ships are operated on regular lines with the necessity of maintaining a prearranged schedule. Even when only nominal speed is required, the insurance of this speed under operating conditions by the sacrifice of a certain amount of deadweight capacity characterizes the design of many of the cargo vessels built since the close of the war—a policy resulting in the production of much healthier and better all-around ships.

In the design of the vessels of which the Shipping Board fleet is comprised the ruling factor seems, in most cases, to have been the attainment of the greatest possible amount of deadweight upon given dimensions and draft, the block coefficients, even for the small lake built vessels, being around 0.78, and for many of the larger ships more than this. The association of these full lined hulls with machinery which could not be economically run at its designed or legend power resulted in a fleet of ships which cannot, in a majority of cases, maintain a sea speed of much more than 9 knots, when fully loaded.

This fact has undoubtedly been a large contributing factor to the difficulty which the Board has experienced in disposing of its ships to private owners. We know of certain cases where the high block coefficient alone has debarred from consideration what were, in other respects, satisfactory ships.

Unfortunately, the block coefficients cannot be changed, but the installation of Diesel engines, of ample power, will enable many of the present government ships to attain a fair sea speed with a much less consumption of fuel than is required by the present machinery in attaining a speed too low to satisfy present day requirements.

For this reason it is to be hoped that the conversion of the Shipping Board vessels to Diesel drive, now about to commence, will be proceeded with as rapidly as circumstances will permit and a fleet of relatively cheap motorships, having what, for the present, may be considered satisfactory speeds, made available.

The time may eventually come when the demand for speed will turn private owners to build new and finer ships notwithstanding the necessity of large expenditures of money. When such a condition is arrived at, the present potential value of the government fleet will be largely negatived. In the meantime, however, these vessels have a very real value and we trust that no effort will be spared in developing and utilizing this value to the fullest possible extent.

While the problem of converting the government ships is a little off the rather academic subject of block coefficient, it serves as an excellent illustration of the close relation of this subject to the eminently practical one of operating commercial vessels and also clearly indicates the present and altogether reasonable and desirable tendency to the construction of speedier, safer and, in general, better ships.

New Ships for the Navy

THE most encouraging piece of news which has come to shipbuilders since the disarmament conference was contained in Admiral Plunkett's statement made at the recent naval architects' banquet that the director of the budget had approved the inclusion of the proposed 10,000-ton cruisers in the naval bill to be acted upon at the next session of Congress. England very greatly outnumbers us in this class of ship and Japan has twice as many as we have. It is incumbent upon this country to maintain the position which has been assigned to it.

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Scrapping Uncle Sam's Warships

By Commander J. N. Jordan, S.C., U. S. N.

U. S. S. Delaware

ONE of the most important provisions of the treaty limiting naval armament affecting the United States was the agreement for disposing of certain vessels in service and under construction. The United States, along with other nations, desired to contribute to the maintenance of the general peace of the world. Accordingly, it agreed to sacrifice a commanding position with reference to the naval supremacy of the sea. The sacrifice of this actual and potential power is represented by the scrapping of 28 capital ships, completed and under construction, and by the conversion of 2 battle cruisers into airplane carriers.

It is not without some regret on his part that an officer of the United States Navy is afforded an opportunity to describe the manner in which the scrapping and the salvage operations have been carried on in disposing of vessels that were designed to be the most formidable ships in existence.

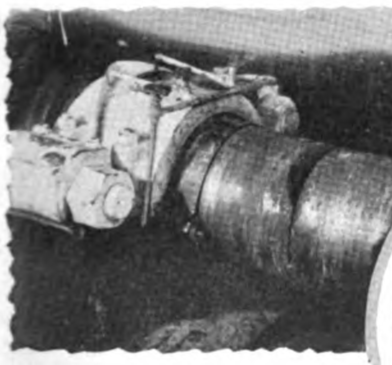
Immediately upon the conclusion of the treaty on February 6, 1922, the Secretary of the Navy, by order of the President, began to take action to carry out its provisions, in conformity with the rules for the scrapping of naval vessels.

On February 8, 1922, in order to save a needless expenditure of money (estimated at $5,000,000 per month), in view of the probable scrapping of certain capital ships, the Secretary of the Navy issued instructions for the suspension of work on vessels building at Navy Yards and private shipyards, and on contracts for guns, armor, etc. The working force on these vessels was reduced to a minimum necessary for the protection of life and property. No steps were taken, however, which would prevent the resumption of the work in case it was decided to complete the vessels.

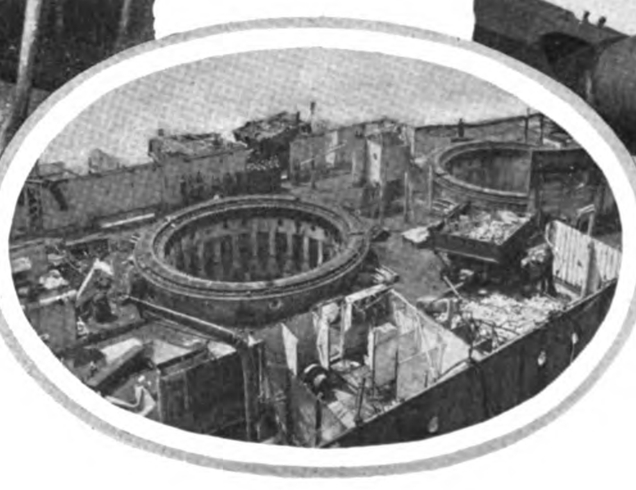
The status of the vessels on April 1, 1922, to be disposed of in accordance with Chapter II, parts 2 and 3, of the treaty, was 17 capital ships in service, 2 of which were in commission, and 4 battle cruisers and 7 battleships building. The ships building varied as to percentage of completion from 4 percent to 75 percent.

Rules for Scrapping

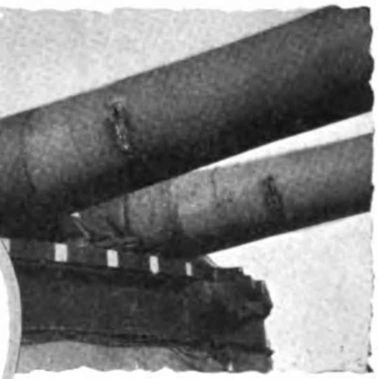
The rules for scrapping of vessels of war, as set forth in Articles II and III of the treaty, required the United States



Crank Shaft Mutilated



Scrapping the Delaware



Guns Disabled

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to dispose of vessels designated to be scrapped in one of the following ways:

(a) Permanent sinking.
(b) Breaking the vessel up. This involved the destruction or removal of all machinery, boilers and armor, and all deck, side and bottom plating.
(c) Converting the vessel to target use exclusively.

The first stage of scrapping required that the vessel should be rendered incapable of further warlike service. This was to be done by removing and landing or else destroying in the ship:

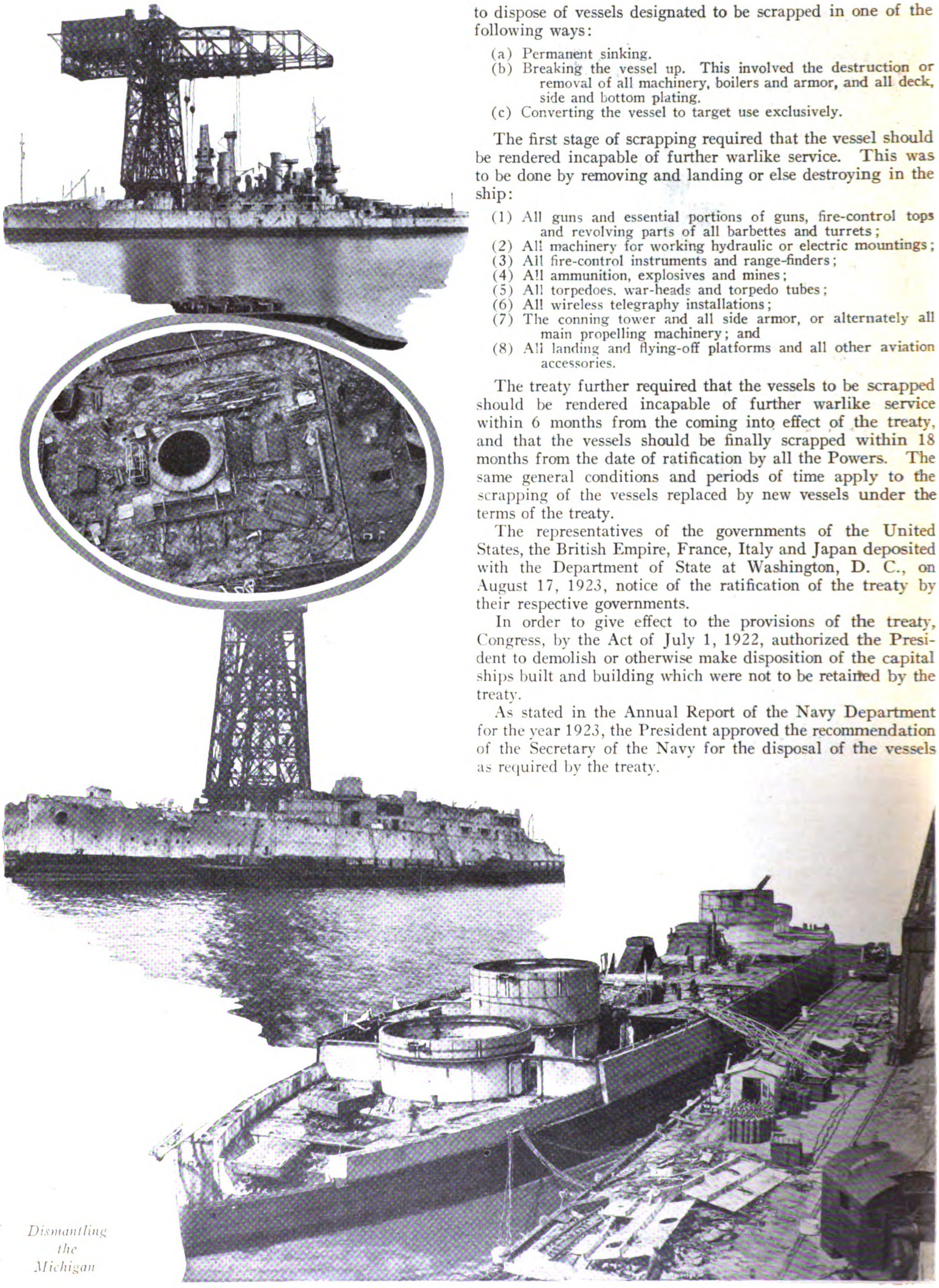
(1) All guns and essential portions of guns, fire-control tops and revolving parts of all barbettes and turrets;
(2) All machinery for working hydraulic or electric mountings;
(3) All fire-control instruments and range-finders;
(4) All ammunition, explosives and mines;
(5) All torpedoes, war-heads and torpedo tubes;
(6) All wireless telegraphy installations;
(7) The conning tower and all side armor, or alternately all main propelling machinery; and
(8) All landing and flying-off platforms and all other aviation accessories.

The treaty further required that the vessels to be scrapped should be rendered incapable of further warlike service within 6 months from the coming into effect of the treaty, and that the vessels should be finally scrapped within 18 months from the date of ratification by all the Powers. The same general conditions and periods of time apply to the scrapping of the vessels replaced by new vessels under the terms of the treaty.

The representatives of the governments of the United States, the British Empire, France, Italy and Japan deposited with the Department of State at Washington, D. C., on August 17, 1923, notice of the ratification of the treaty by their respective governments.

In order to give effect to the provisions of the treaty, Congress, by the Act of July 1, 1922, authorized the President to demolish or otherwise make disposition of the capital ships built and building which were not to be retained by the treaty.

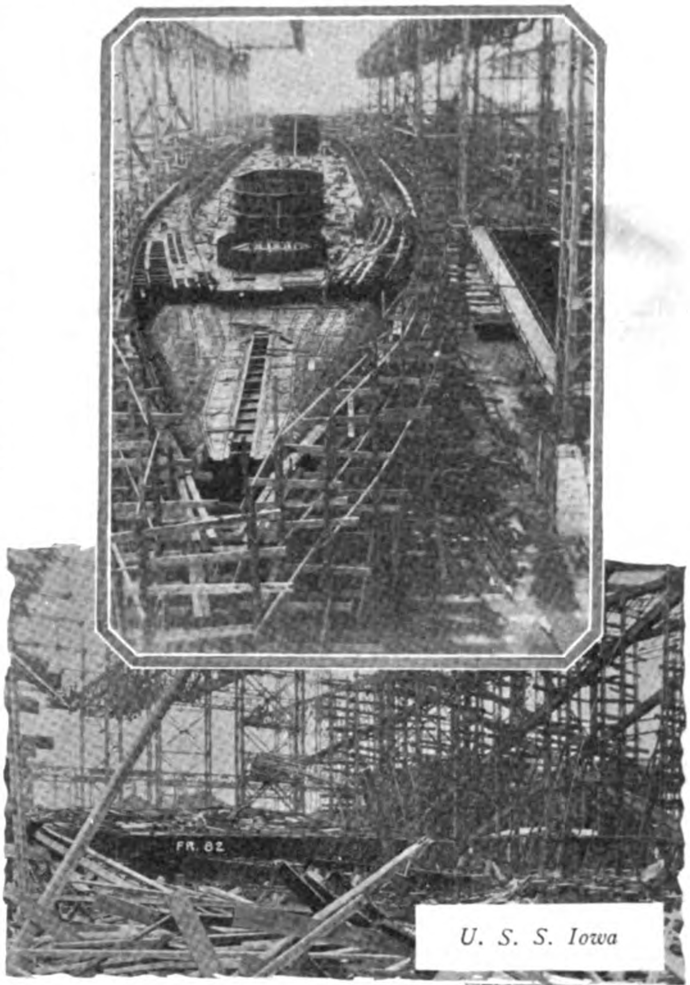
As stated in the Annual Report of the Navy Department for the year 1923, the President approved the recommendation of the Secretary of the Navy for the disposal of the vessels as required by the treaty.



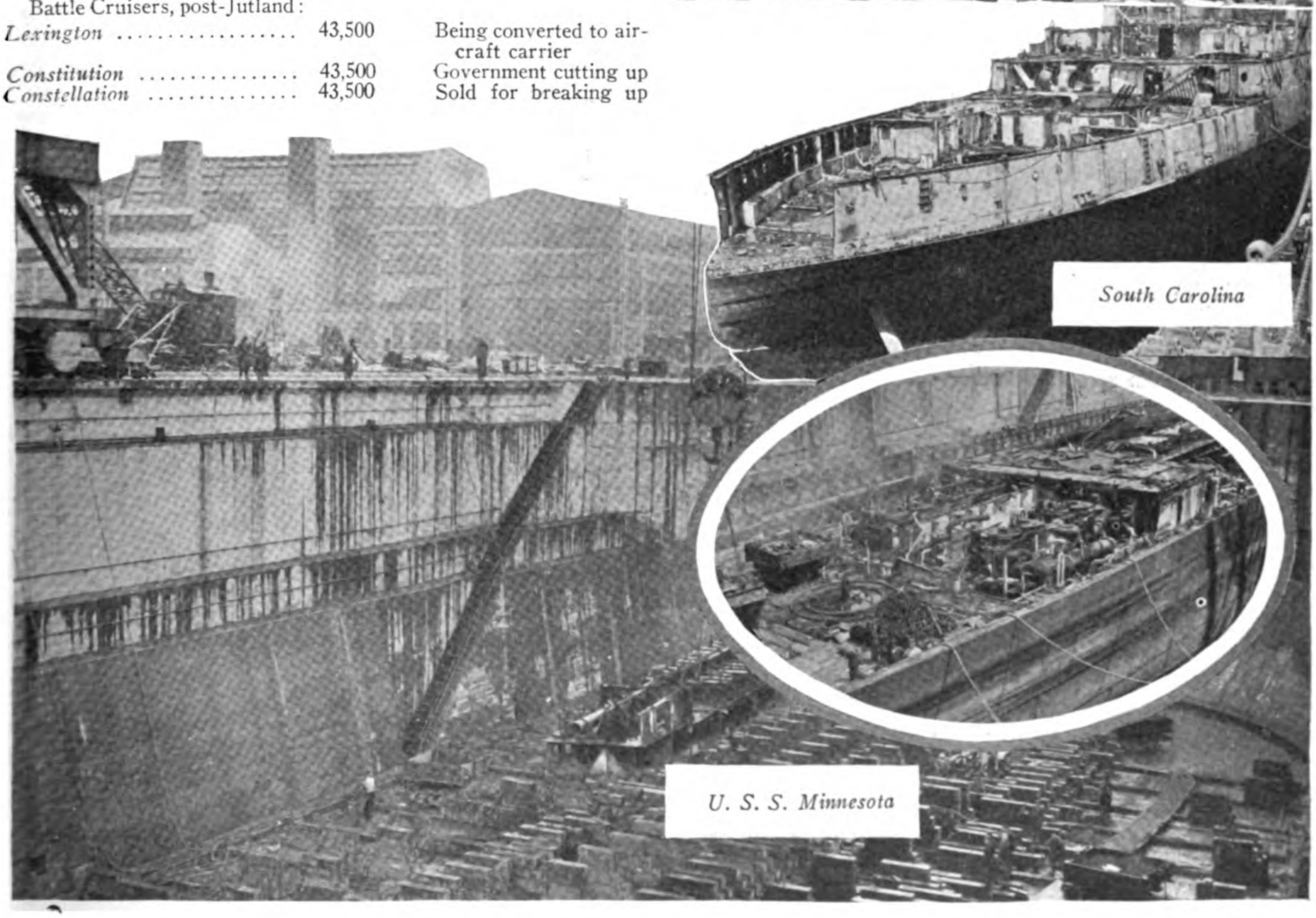
Dismantling the Michigan

The vessels were rendered incapable of further warlike service prior to February 17, 1924. The work of scrapping or otherwise disposing of these vessels is now in progress. No difficulty is contemplated in the completion of this work prior to February 17, 1925, the expiration of the eighteen months period, as indicated below from an official report of the Navy Department, dated June 17, 1924:

NAME OF VESSEL	TONNAGE	DISPOSITION
Battleships, pre-Jutland:		
Maine	13,500	Sold for breaking up
Missouri	13,500	Sold for breaking up
Virginia	16,094	Sunk
Nebraska	16,094	Sold for breaking up
Georgia	16,094	Sold for breaking up
New Jersey	16,094	Sunk
Rhode Island	16,094	Sold for breaking up
Connecticut	17,666	Sold for breaking up
Louisiana	17,666	Sold for breaking up
Vermont	17,650	Sold for breaking up
Kansas	17,650	Being cut up by Philadelphia Navy Yard
Minnesota	17,650	Being cut up by Philadelphia Navy Yard
New Hampshire	17,784	Sold for breaking up
South Carolina	17,617	Being cut up by Philadelphia Navy Yard
Michigan	17,617	Being cut up by Philadelphia Navy Yard
Delaware	20,000	Being cut up by Philadelphia Navy Yard
North Dakota	20,000	To be converted to target ship
Battleships, post-Jutland:		
Washington	32,600	To be sunk
South Dakota	43,200	Being cut up by New York Navy Yard
Indiana	43,200	To be sunk
Montana	43,200	Sold for breaking up
North Carolina	43,200	Sold for breaking up
Iowa	43,200	Sold for breaking up
Massachusetts	43,200	Government cutting up
Battle Cruisers, post-Jutland:		
Lexington	43,500	Being converted to aircraft carrier
Constitution	43,500	Government cutting up
Constellation	43,500	Sold for breaking up



U. S. S. Iowa



South Carolina

U. S. S. Minnesota

Name of Vessel	Tonnage	Disposition
Saratoga	43,500	Being converted to aircraft carrier
Ranger	43,500	Sold for breaking up
United States	43,500	Government cutting up

Removal of Material from Completed Vessels

While the actual disposal of all the aforementioned vessels by sinking, sale and scrapping was deferred until all the Powers had notified the United States of the ratification of the treaty by their respective governments, a vast amount of preliminary work was done by the Navy in planning for the disposition and sale of the vessels, removing usable material and equipment from completed vessels and in preparing inventories of materials for vessels under construction.

Inventories

Under direction of the Bureaus of Construction and Repair and Engineering, which bureaus have direct charge of the hull and machinery construction of vessels building and the maintenance of similar equipment for vessels afloat, information and reports were obtained from the navy yards, naval inspectors and contractors as to the status of the work under orders and contracts. Standard inventory forms were adopted to assist in determining the disposition of material and to provide information for the preparation of a list of material for sale. This information was also used in connection with the preparation and settlement of cancellation claims. The inventories certified by the naval representatives covered more than 10,000 forms and over 100,000 different items were listed. Each article and different kind of material was listed separately. The lists described in detail the kind and quantity of material on hand and the status of the order.

The expense of inventorying and handling material was reduced to a minimum consistent with proper protection. Small valuable articles were packed in boxes and marked. Articles of little value and small quantities of material, where the cost of handling, listing, checking and accounting, sale or shipping did not warrant the expense, were scrapped. All such material, however, was accounted for on the inventories made. Upon receipt of the inventory and status sheets by the bureau concerned, the lists were gone over and instructions issued as to the disposition of material and the cancellation or completion of orders. It is estimated that the appraised value of equipment removed from completed vessels and the material transferred from vessels building for the future use of the treaty Navy has exceeded $1,000,000.

Sale

The material and equipment which could be used by the Navy, having been removed from the completed vessels and set aside from the ships building, the Bureau of Supplies and Accounts conducted the sale of the vessels directed to be sold. The principal difficulty experienced by the bureau in disposing of the vessels was not in obtaining purchasers for so large a quantity of scrap material offered for sale at one time, but the difficulty in getting firms to bid that could be relied upon to cut up and destroy the vessels within 18 months from August 17, 1923.

The ship-breaking and the salvaging of obsolete naval vessels has become a new industry since the end of the World War and very little experience had been obtained on this work in the United States up to the time the vessels were offered for sale. By the use of the oxy-acetylene torch and electric arc cutting equipment, whole sections of the vessels are readily cut out and later reduced to shipping sizes. Heavy armor plate and guns have been cut with little difficulty. The number of men employed in breaking up vessels has varied from 30 to 150, depending upon the condition of the vessels. When all the superstructure and other material has been removed from ships, down to the waterline, they are beached at high tide and the scrapping operations continued at low tide. This operation is repeated until the work of demolishing the vessels has been completed. On some vessels the final cutting operations are being performed on the hulls in dry dock.

To assist in disposing of the vessels and to obtain better prices, the work of cutting up some of the vessels has been carried on by the navy yards and the government at shipyards. The scrap material was sold cut in shipping or charging box size.

The following prices have been received in the sale of scrap material cut up: $14.05 per ton for ferrous metal, $0.08975 per pound for non-ferrous and $14.10 per ton for armor plate.

The Bureau of Supplies and Accounts prepared and distributed a series of catalogues describing in detail the conditions pertaining to the sale of the vessels. The bureau also issued pamphlets describing how "ship-breaking" was done in Great Britain. The terms of sale required the purchaser to complete the scrapping of the vessels within 18 months from August 17, 1923, in accordance with the rules for scrapping. The Navy Department reserved the right to investigate the salvaging of the vessels and, if sufficient progress had not been made at the end of one year to insure complete demolition of the vessels within the period specified, the government reserved the right to assume control and dispose of the vessel or vessels, as required by the treaty.

Advertisements relative to the sale of the ships were placed in daily and commercial papers, giving wide publicity and information to those desiring to engage in ship-breaking and the purchase of scrap materials.

On the dates set for the opening of the sealed bids there was found to be a lively competition for the purchase of the vessels. The prices obtained were commensurate with the market prices for scrap materials, taking into account the cost of breaking up and the extended period required for the work.

The total sales price of 22 vessels sold on the basis of the actual or approximate quantity of material sold, and delivered to date, is $1,994,513.52. The total expense incurred in connection with advertising the vessels for sale and the estimated cost of cutting up the vessels for sale as material on a tonnage basis is $436,922.86. The estimated net receipts from the sale of the vessels is, therefore, $1,557,590.66. It was found that much better prices were obtained for the vessels sold cut-up on a tonnage basis than that received for vessels sold "as is" or complete but rendered unfit for further service.

In addition to the amounts received from the sale of the completed vessels and fabricated portion of ships under construction, large quantities of surplus material and left-over material transferred from the scrapped ships have been disposed of by separate sales held on Navy surplus materials.

Settlement of Cancellation Claims

After the approval of the Act of Congress on July 1, 1922, authorizing the President to scrap certain vessels in conformity with the provisions of the treaty, many of the orders for materials for vessels building were cancelled. The contracts for construction and propelling machinery, however, were not cancelled until August 17, 1923, the date on which the United States was notified that all the Powers had ratified the treaty.

The authority given to the President by Congress in the Act of July 1, 1922, to cancel contracts for the construction of vessels, provides that the claims of the contractors due to cancellation should be settled on a "fair and equitable basis."

A board of officers was appointed by the Secretary of the Navy to recommend the terms of settlement of the claims arising from the cancellation of the contracts. The officers constituting this board were: Rear Admiral W. L. Capps, C.C., U. S. N., Senior Member of the Compensation Board; Rear Admiral David Potter, S.C., U. S. N., Paymaster General of the Navy; Rear Admiral J. K. Robison, U. S. N., Engineer-in-Chief of the Navy; Rear Admiral J. D. Beuret, C.C., U. S. N., Chief Constructor of the Navy; Captain William McEntee, C. C., U. S. N.; and Commander J. N. Jordan, S. C., U. S. N.

The board, known as the Cancellation Board, gave careful consideration to the claims of the contractors and made detailed investigation of the claims, with the assistance of the bureaus and of the long-standing Compensation Board. The Compensation Board is charged with the duty of estimating, ascertaining and determining the costs in accordance with the terms of the contracts with private shipyards for the construction of vessels on a "cost plus profit" basis.

The suspension of work and the cancellation of contracts seriously affected the business conditions of the shipyards and of contractors furnishing materials and equipment for the vessels under construction. In many cases, it greatly reduced plant production and required a readjustment of the plant organization by a reduction in force and the development of entirely new lines of product. The shipbuilding industry of the country, which has been relatively at a standstill in the building of merchant vessels for several years, was the hardest hit by the cancellation of the contracts for 5 capital ships.

The contractors' claims varied as to the nature of the losses sustained and in amounts claimed. A great deal depended on the conditions of the contractor's business and the effect of the suspensions and cancellations on the orders in hand and work in progress. In some cases, the settlement was only a matter of examining the contractor's books and determining that the amounts claimed were correct. In some cases, the settlement was made on a physical estimate of completion applied to the contract price. In other cases, after records had been checked and accurate information obtained, it involved questions of judgment to arrive at settlements with the contractor upon a "fair and equitable basis."

The total amount of the claims presented due to the cancellation of contracts for the construction of the five vessels building at private shipyards and the claims of subcontractors for materials on orders placed by these yards and the navy yards exceeded $27,000,000. The amount found due in settlement of all of these claims and accepted by the contractors by June 30, 1924, was approximately $16,025,000.

The settlements of the claims for ordnance material, including orders for guns, armor, etc., were handled by a "Special Board on Adjustment and Cancellation of Ordnance Contracts" with the assistance of the Bureau of Ordnance and Bureau of Supplies and Accounts, in accordance with the policy laid down by the Secretary of the Navy. A reduction of $500,000 was made in the settlements from the estimated amount required for the settlement of the ordnance claims due to cancellation. The total amount found due in the settlement of all the ordnance claims was $7,950,000.

Savings Effected by Reduction in Armaments

That the United States has been able to reduce the expenditure in money by the limitation of naval armaments is a self-evident fact. However, it is possible that still greater saving might have been made by the retention of some of the battleships under construction, to replace the older type of vessels now in the service, such as the *Florida*, *Utah*, *New York*, *Texas*, *Arkansas* and *Wyoming*. The cost of maintaining these older type of vessels is large and the vessels require extensive alterations and repairs to make them effective units of the fleet.

If the benefit to the United States of the Treaty Limiting Naval Armaments is to be estimated in terms of dollars by the estimated reduction in expenditures, the following data may serve as a basis for arriving at such an estimate:

The book value of the 17 vessels in service which were scrapped is estimated at $104,534,000. The cost of maintaining these vessels in commission would be more than $25,000,000 per annum. It is possible, however, that a large number of these vessels would have been placed out of service upon the commissioning of all the ships constructed under the 1916 building program.

The more definite savings are, therefore, represented by not completing the 7 battleships and 4 battle cruisers under construction, as follows:

Total estimated cost of 7 battleships and 4 battle cruisers, with their machinery, armor, guns and ammunition	$437,000,000
Expenditures made in connection with construction of the vessels, including machinery, armor, guns and ammunition	$154,000,000
Required to complete, if vessels not scrapped	$283,000,000
Estimated cost of scrapping	$ 28,000,000
Estimated savings on construction cost to complete less cost of scrapping	$255,000,000

The annual cost of maintenance of these vessels upon being placed in commission, including the pay and subsistence of personnel, fuel, repairs and upkeep and other charges made directly to the vessels is estimated to be between $25,000,000 and $30,000,000.

The savings effected in money must also be considered together with loss of the sea power of the United States that should be maintained for our own security and the enforcement of justice by all nations in world affairs. The protection and service rendered in peace and war by the military and naval forces of the United States fully justify their existence when considered in connection with the present national welfare and the country's influence in world affairs for the benefit of mankind.

The Navy of the United States, in accordance with the latest reports, is falling behind its proper position as the equal of any naval power in the world. It should be brought up to the 5-5-3 standard allowed by the treaty, not only in tonnage but also in effective force, by the addition of scout cruisers and the reconditioning of the ships in commission. Adequate appropriations should be provided for fleet maintenance and operation. It is believed to be generally conceded that any additional limitation of our naval power should not be undertaken without due consideration being given to the reduction in naval offensive power by other nations and to the protection of our own coast line and the sea-borne commerce of the United States.

Scrapping by Other Powers

The progress made by the other Powers in carrying out the scrapping provisions of the Treaty Limiting Naval Armaments compares favorably with the efforts made by the United States. The treaty required only Japan, Great Britain and the United States to reduce the tonnage of capital ships in service and abandon the construction of vessels laid down and authorized. It was agreed that France and Italy could retain the existing tonnage of their navies and increase the tonnage in capital ships up to certain limitations. According to the reports on file in the office of Naval Intelligence of the Navy Department, the progress made in the disposition of vessels designated to be scrapped by Japan and the British Empire is as follows:

British Empire

Name of Vessel	Tonnage	Disposition
Battleships, pre-Jutland:		
Commonwealth	16,350	Sold for breaking up
Dreadnought	18,500	Sold for breaking up
Agamemnon	16,500	To be converted to a target ship
Bellerophon	18,600	Sold for breaking up
St. Vincent	19,250	Sold for breaking up
Superb	18,600	Sold for breaking up
Neptune	19,900	Sold for breaking up
Hercules	20,000	Sold for breaking up

Name of Vessel	Tonnage	Disposition
Temeraire	18,600	Sold for breaking up
Conqueror	22,500	Sold for breaking up
Monarch	22,500	To be used for experimental purposes
Orion	22,500	Sold for breaking up
Agincourt	27,500	Sold for breaking up
Erin	23,000	Sold for breaking up
Colossus	20,000	Retained for non-combatant purposes
Collingwood	19,250	Sold for breaking up
Battle Cruisers, pre-Jutland:		
Inflexible	17,250	Sold for breaking up
Indomitable	17,250	Sold for breaking up
New Zealand	18,800	Sold for breaking up
Lion	26,350	Sold for breaking up
Princess Royal	26,350	Sold for breaking up
Australia	18,800	Sunk

Battle Cruiser Contracts Cancelled

Work was suspended on 4 battle cruisers of 44,000 tons displacement, authorized and building, on November 17, 1922, and these contracts have since been cancelled. Two ships of 35,000 tons displacement are to replace 4 battleships of the *King George V* type.

Japan

Name of Vessel	Tonnage	Disposition
Battleships, pre-Jutland:		
Hizen	12,700	Guns and armor removed and sunk
Mikasa	15,200	Guns and armor removed and sunk
Kashima	16,400	To be sold
Katori	15,950	To be sold
Satsuma	19,350	To be sunk
Aki	19,800	To be sunk
Settsu	20,800	Retain for target practice
Disarmament completed, now equipped as a towing vessel.		
Kaga	39,900	To be sunk
Launched but not completed.		
Tosa	39,900	Sunk
Launched but not completed.		
Armored Cruisers:		
Koma	14,600	Sold for breaking up
Ibuki	14,600	Sold for breaking up
Kurama	14,600	Sold for breaking up
Battle Cruisers:		
Amagi	44,000	Being converted to airplane carrier
Akagi	44,000	Being converted to airplane carrier
Takao—not launched	44,000	Construction abandoned
Atago—not launched	44,000	Construction abandoned

Projected construction of eight ships not laid down, abandoned.

Asahi (non-combatant purposes) *Yokosuka.*

The tonnage of vessels indicated above is that used in the Navy Year Book for 1920-1922.

Conclusion

In carrying out the scrapping provisions of the treaty for the United States, as described above, the Navy has accomplished a large and difficult undertaking in an expeditious manner, for the best interest of the country. It not only reflects credit on the administrative ability of the Navy Department of the Government, but due recognition should be given to the shipbuilding and allied industries and trades which have sacrificed profitable contracts and remunerative employment by their co-operation and efforts to accomplish what has been spoken of as "an experiment in human civilization."

It is hoped that the fulfillment of these conditions of the Treaty by all the Powers will have its good effect on the peace of the world, and will fortify the mutual trust and confidence in the ability of nations to comply with peacetime agreements, no matter what the compelling interest may be that has led to such agreements.

Adapting Arc Welding Apparatus to Ship Use

THE Electric Arc Welding & Cutting Company, Newark, N. J., has developed a portable arc welding unit which is made to operate without moving parts from a ship's generating line, anywhere on a ship. The apparatus can be moved about the ship by hand, especially into inaccessible places about the cargo.

The many uses to which the arc welding process may be applied for rapid repairs and in emergencies require no comment. The apparatus in question, which makes possible the application of the electric arc process aboardship, consists of a regulating apparatus with necessary control meters, switchboard, etc. The generator is dispensed with in favor of the ship's generator, which is of sufficient capacity to supply current for welding. Because the ship's generator alone has not the proper characteristics, it is necessary to use some such system as that contained in the portable apparatus described to convert the regular ship power supplied into the proper electrical heat control for arc welding. The apparatus will not operate from a lamp socket but can be used from the ship's mains wherever they can be reached aboard. There are two leads marked "connect to the power line" and two leads for "welding" so that no special knowledge is required to connect the apparatus.

Portable Arc Welding Unit

Sinking of Warship Upheld by Court

Washington, D. C.

JUSTICE HITZ of the District of Columbia supreme court on November 14 refused to issue an injunction asked by William B. Shearer, a naval expert of New York, to prevent Secretary Wilbur of the Navy from proceeding with plans for the destruction of the battleship *Washington* as provided for by the Washington arms conference treaty. The injunction had been asked by Mr. Shearer as a taxpayer to prevent the sinking of the ship in bombing tests in which it was to be used as a target and, as he said, in an effort to gain time for Congress to act on the matter.

The justice sustained a motion filed on behalf of the Secretary of the Navy that the suit be dismissed for want of equity and on the ground that the court had no jurisdiction over the matter.

Counsel for Mr. Shearer noted an appeal to the district court of appeals.

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A Diesel Electric Tug Boat[*]

Comparative Tests of Diesel Electric, Direct Diesel and Steam Driven Tugs

By Frank L. DuBosque

TUGBOATS operated by the railroads may be divided into four classes:

1. The tug used in moving barges from one berth in a dock to another or to a berth in an adjacent dock where the barge can be conveniently loaded or unloaded; commonly known as the "Drill" tug, a boat about 75 feet long and of about 250 indicated horsepower.

2. The tug used in assembling and towing car floats and barges from a rail terminal to distant piers where the freight is unloaded; commonly known as a "Float" tug, a boat slightly over 100 feet long and of about 750 indicated horsepower.

3. The tug used in towing carfloats exclusively from one rail terminal to another; commonly known as a "Transfer" tug, a boat about 115 feet long and of 900 indicated horsepower.

4. A few tugs are used to tow barges and scows comparatively a long distance—30 miles—a flotilla of twelve to fourteen boats towed on a hawser being brought to a designated point in the harbor and from there distributed by the "Float" tug. This tug is about the same size as the "Transfer" tug, but of slightly different characteristics, as this is the only class on which the crews live.

Realizing the fuel economy that can be obtained by the use of the Diesel-type engine as compared with the steam engine, a four-cylinder Diesel engine was installed in a Pennsylvania Railroad tugboat about seven years ago. It failed to produce the power expected and was removed. During the trials it was found necessary to install a wheel of quite small diameter to obtain the prescribed speed of revolution for which the engine was designed, and while the engine could be started, stopped and reversed satisfactorily, the wheel did not accelerate or retard the speed of the boat and its tow quickly, and the maneuvering qualities were so sluggish, therefore, that the owners decided that the system where a Diesel engine is directly connected to the propeller was not a satisfactory system for a tug employed to a large extent in maneuvering, because of the relatively small diameter of wheel inherent with the fast-running Diesel engine.

ADVENT OF THE DIESEL ELECTRIC SYSTEM

Until recently very little has been produced in large tugboats where the so-called straight Diesel-type self-reversible engine was incorporated. Several small power installations exist where reversible clutches are used. The advent of the "Diesel electric" system opened a new field. With this system power is furnished to an electric motor attached to the propeller shaft, and the motor can be designed for an efficient propeller speed and can be controlled directly by the navigator of the boat, a feature which comparatively reaches the highest degree of importance on some classes of tugboats, notably the "Float" tug whose functions were previously described. In picking up boats to be towed and placing them in their berth, these tugs work in crowded docks and considerable maneuvering is required. Frequent signals are given by the pilot to the engineer, and a mistaken signal or an incorrect response results in delay, and frequently in damage. What is more important, no signal is given that will convey information as to the exact speed of revolutions desired for a contemplated movement.

Observation on several "Float" tugs showed that on an average 566 signals were given and answered during an eight-hour watch, which means an average of one every fifty-one seconds. This frequency of signals and their importance is generally underestimated by those in charge of tug operations, and to illustrate the frequency Fig. 1 is prepared to show graphically the number and the time signals were given on a tug performing one "order," picking up and delivering four barges. (These barges average 100 feet long and 32 feet beam.) It will be noted that there are periods when six signals are given in a minute, that about one-third of the total time was required to pick up the barges, and the average period between signals was nineteen seconds. A little over one-third of the time was required to deliver the barges, and signals averaged sixteen seconds. Much of this manipulation of the engine and its accompanying objections would be eliminated if the speed of the propeller could be controlled directly by the pilot so as to give the tug the proper degree of movement in either direction when maneuvering, a feature that could be obtained by turning the propeller shaft by an electric motor. It was this feature principally that prompted the installation of a Diesel electric drive on this tug. The known economy that would obtain with the Diesel engine while important, was considered of secondary importance.

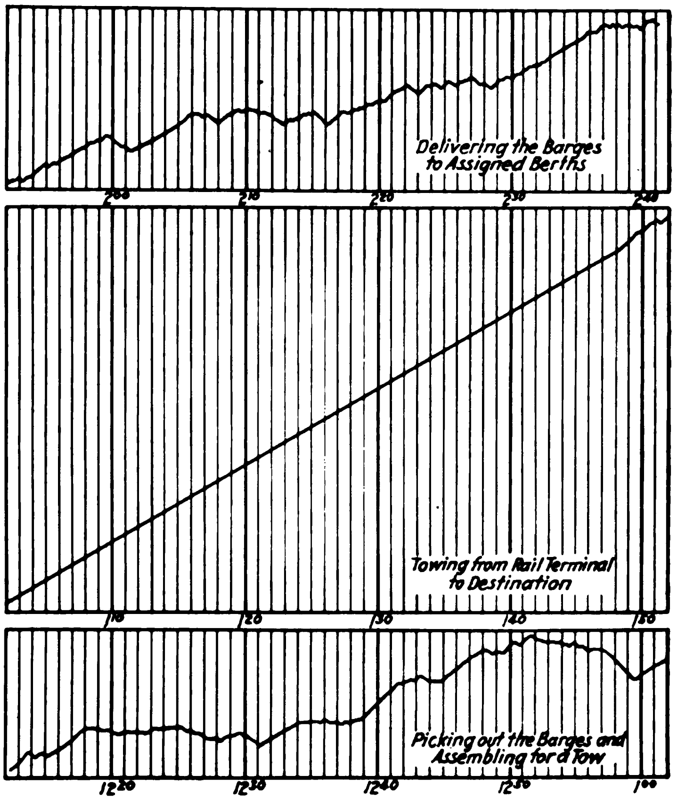

Fig. 1.—Graphic Illustration of the Signals Given by the Pilot to the Engineer on a Steam Tug with Typical Tow of Four Barges from Rail Terminal to Destination

A "Float" tug was selected for the installation because this class contains about 80 percent of all the railroad tugs, and, as has been described, is largely employed in maneuvering. The size, shape and power were designed to be similar to the standard design of steam engine propelled tug now in use. The size, shape and detail construction are shown in Figs. 2 and 3. The hull, waist, fenders and superstructure are built of steel; in fact, no wood is used except to form the rail.

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[*] Paper read before the Society of Naval Architects and Marine Engineers, New York, November, 1924.

Machinery Installation on P. R. R. No. 16

The motive power is furnished by two Winton full Diesel engines, four cycle, each having six cylinders, 13¼ inches diameter, 18 inches stroke, rotating continuously in one direction and automatically governed as to rotative speed. All auxiliaries needed in the operation of these engines are attached to them. The engines at rest are started by air; when one engine is in motion the other can be started electrically. Each engine is directly connected to a Westinghouse direct-current, shunt-wound generator, rated at 235 kilowatts at 250 volts, running 260 revolutions per minute, and has attached to it a 25 kilowatt compound wound excitor. The generators operating in series furnish current for the propelling motor, and the excitors, in addition to exciting the generators, furnish current for all other power needed on the boat.

The propelling motor is of the shunt-wound, double-armature type, rated at 575 horsepower, at 500 volts and 125 revolutions per minute. The propeller is of cast iron, 9 feet 6 inches diameter, 9 feet 4 inches pitch. The rudder is turned by a 7.5 horsepower motor-driven steering machine of the simple hoisting type, operated on the non-follow-up system. Light is furnished by storage batteries automatically charged by a 2-kilowatt motor generator set. The boat is heated by passing air around the muffler attached to the exhaust pipes of the main engines, and then through ducts to the location desired. A No. 2 Sirocco fan driven by a 1-horsepower motor is used to circulate the air. The whistle is sounded by compressed air taken from a storage tank supplied from the second stage air compressor on the main engine. A Klaxon horn was tried but was not satisfactory.

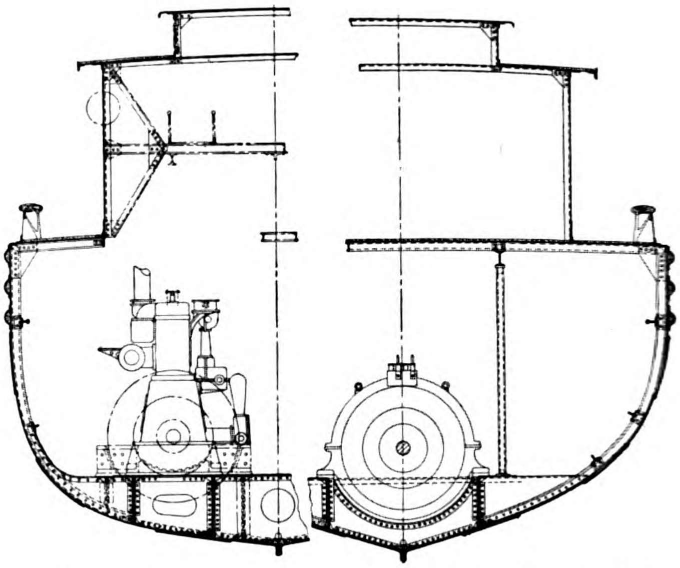


Fig. 3.—Transverse Sections of Tug P. R. R. No. 16; (Left) Looking Forward Through Engine, (Right) Looking aft Through Motor

Method of Control

The rotation of the propelling motor is controlled on the Ward-Leonard system of variable generated voltage, so that any speed from minimum to maximum can be instantly obtained by the appropriate movement of a single lever on the control stands. Two control stands are erected in the pilot house, one on either side, and the levers operate in unison, so that the pilot can act from either side of the boat, a feature necessary on a tugboat. For the same reason a steer-

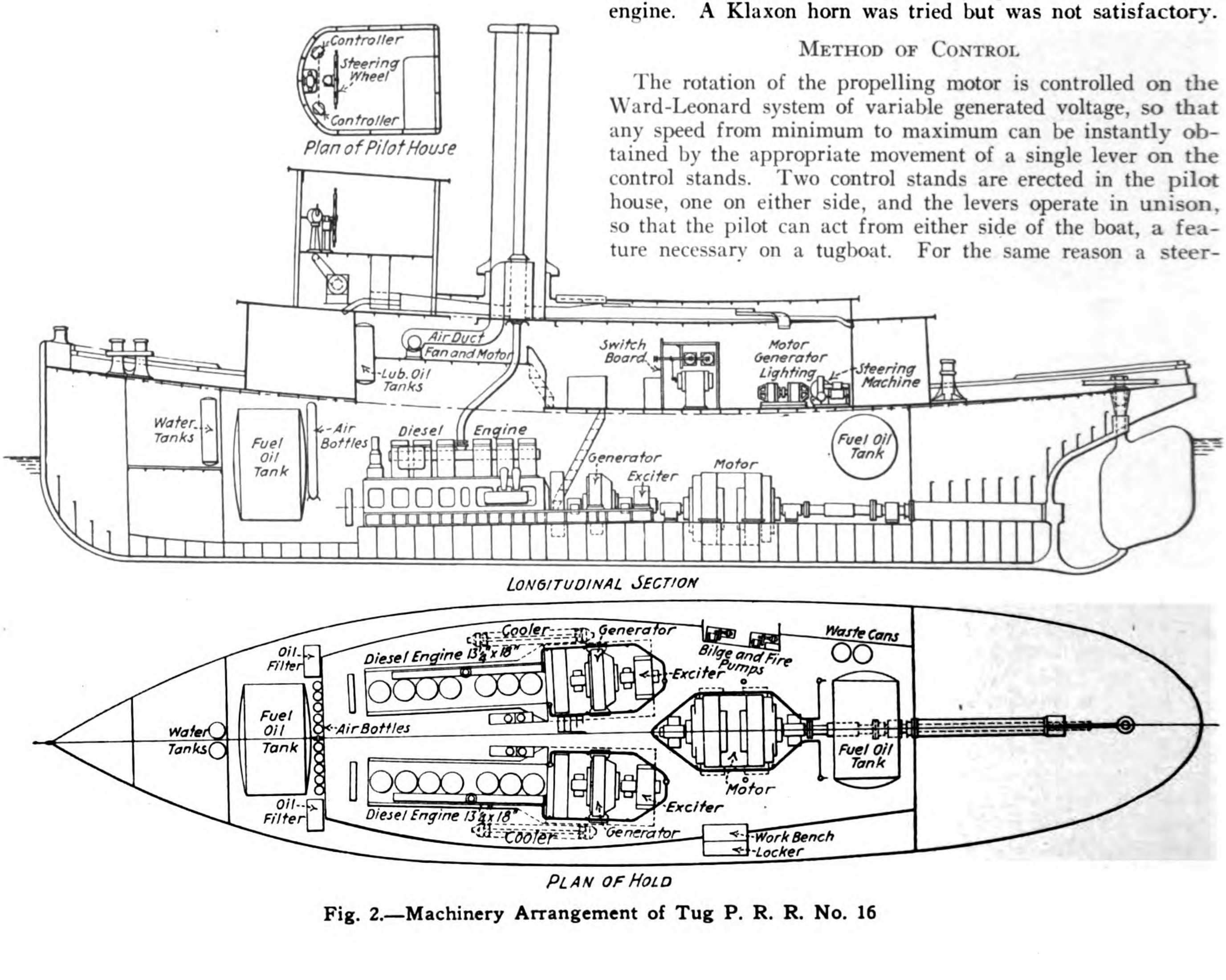

Controller
Steering Wheel
Controller
Plan of Pilot House
Air Duct
Fan and Motor
Lub. Oil Tanks
Switch Board
Motor Generator Lighting
Steering Machine
Water Tanks
Fuel Oil Tank
Air Bottles
Diesel Engine
Generator
Exciter
Motor
Fuel Oil Tank
LONGITUDINAL SECTION
Cooler
Generator
Waste Cans
Oil Filter
Diesel Engine 13¼" x 18"
Bilge and Fire Pumps
Exciter
Fuel Oil Tank
Water Tanks
Air Bottles
Fuel Oil Tank
Motor
Oil Filter
Diesel Engine 13¼" x 18"
Exciter
Cooler
Generator
Work Bench
Locker
PLAN OF HOLD

Fig. 2.—Machinery Arrangement of Tug P. R. R. No. 16

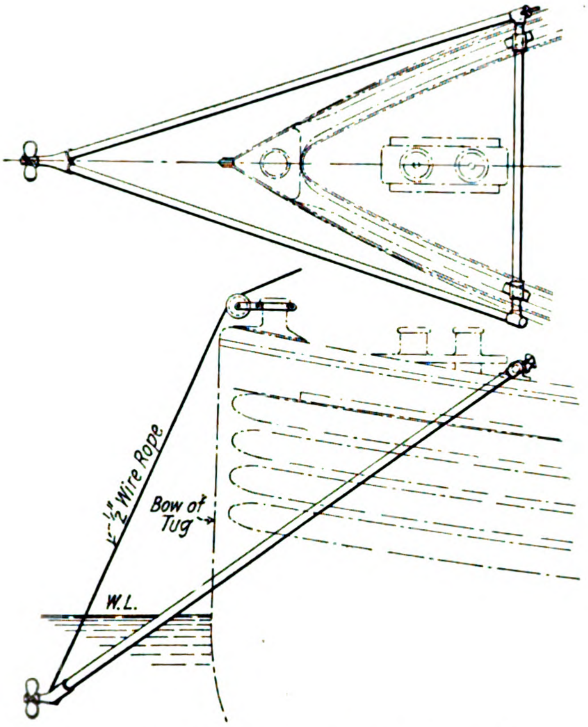

1/2" Wire Rope
Bow of Tug
W.L.

Fig. 4.—Speed Measuring Device Used on Tug Boat Trials

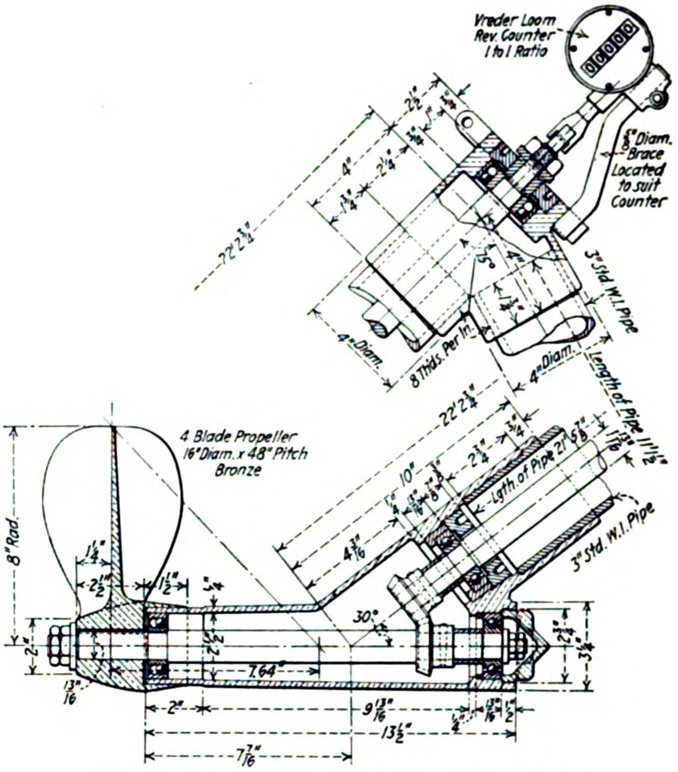

Vreder Loom Rev. Counter 1 to 1 Ratio
5/8" Diam. Brace Located to suit Counter
3" Std. W.I. Pipe
Length of Pipe 11' 1/2"
22' 2 3/4"
4" Diam.
8 Thds. Per In.
4 Blade Propeller 16" Diam. x 48" Pitch Bronze
8" Rad.
Lgth. of Pipe 21' 5 5/8"
3" Std. W.I. Pipe
30°
7.64"
9 13/16"
13 1/2"
7 7/16"

Fig. 5.—Details of Speed Measuring Device

ing wheel 4 feet 6 inches in diameter is used instead of a lever to operate the rudder, so that both the rudder and propeller can be conveniently operated when the pilot finds it necessary to confine his vision to the boat's side instead of ahead, as he frequently does in picking up and handling a tow.

The tug was completed on July 8, 1924, and is believed to be the first Diesel-electric screw-propelled tug constructed.

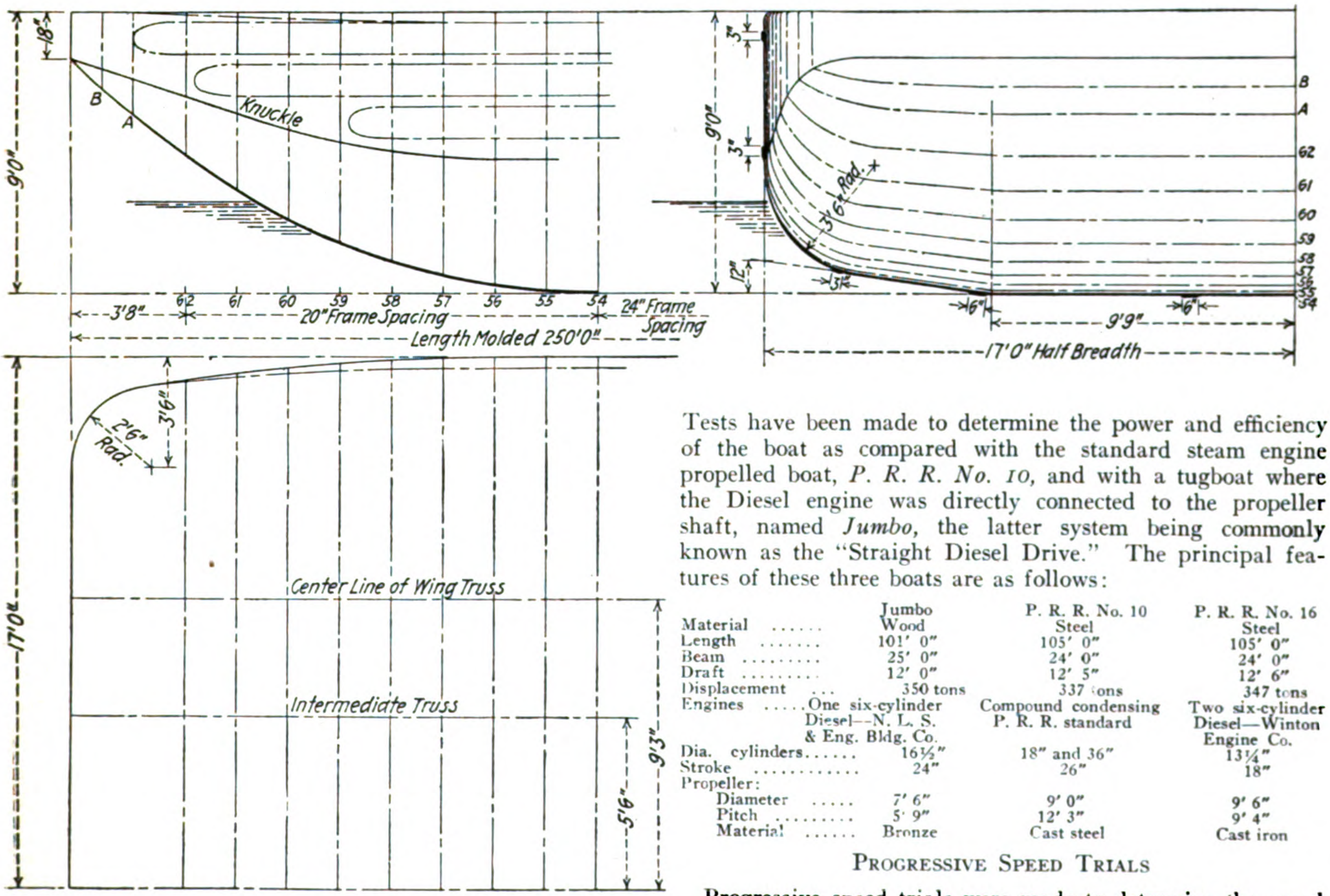

18"
9'0"
B
A
Knuckle
3'8"
62
61
60
59
58
57
56
55
54
20" Frame Spacing
24" Frame Spacing
Length Molded 250'0"
3"
9'0"
3"
3'6" Rad.
12"
6"
9'9"
6"
17'0" Half Breadth
3'6"
2'6" Rad.
17'0"
Center Line of Wing Truss
Intermediate Truss
5'6"
9'3"

Fig. 6.—Form of Hull of Carfloat Used in Tug Boat Trials

Tests have been made to determine the power and efficiency of the boat as compared with the standard steam engine propelled boat, *P. R. R. No. 10,* and with a tugboat where the Diesel engine was directly connected to the propeller shaft, named *Jumbo,* the latter system being commonly known as the "Straight Diesel Drive." The principal features of these three boats are as follows:

	Jumbo	P. R. R. No. 10	P. R. R. No. 16
Material	Wood	Steel	Steel
Length	101' 0"	105' 0"	105' 0"
Beam	25' 0"	24' 0"	24' 0"
Draft	12' 0"	12' 5"	12' 6"
Displacement ...	350 tons	337 tons	347 tons
Engines	One six-cylinder Diesel—N. L. S. & Eng. Bldg. Co.	Compound condensing P. R. R. standard	Two six-cylinder Diesel—Winton Engine Co.
Dia. cylinders......	16½"	18" and 36"	13¼"
Stroke	24"	26"	18"
Propeller:			
Diameter	7' 6"	9' 0"	9' 6"
Pitch	5' 9"	12' 3"	9' 4"
Material	Bronze	Cast steel	Cast iron

PROGRESSIVE SPEED TRIALS

Progressive speed trials were made to determine the speed of each boat running free and with a tow, the stress on the

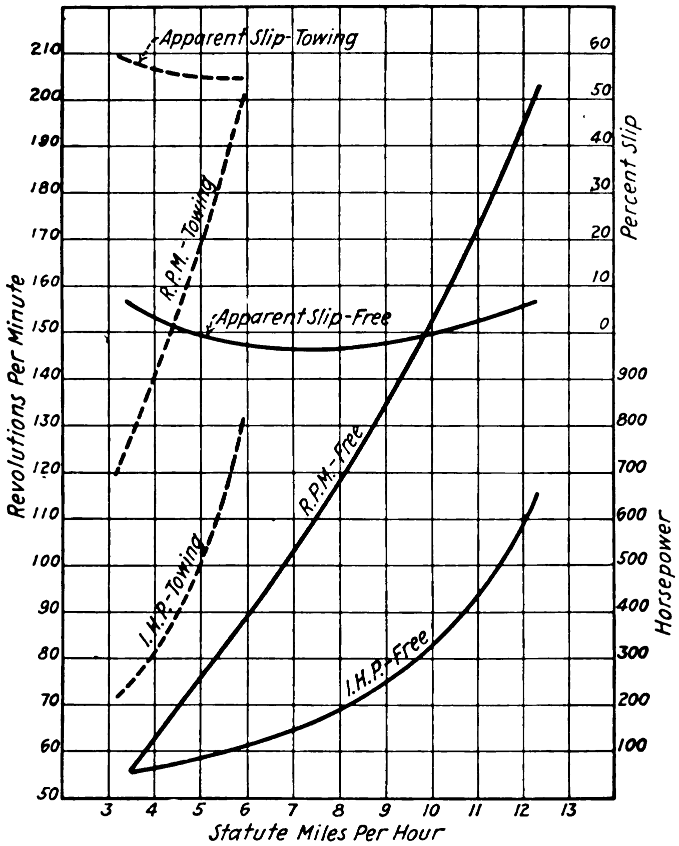


Fig. 7.—Chart Showing Horsepower, Revolutions of Screw Propeller and Apparent Slip of Tug Jumbo at Different Speeds, Towing and Running Free

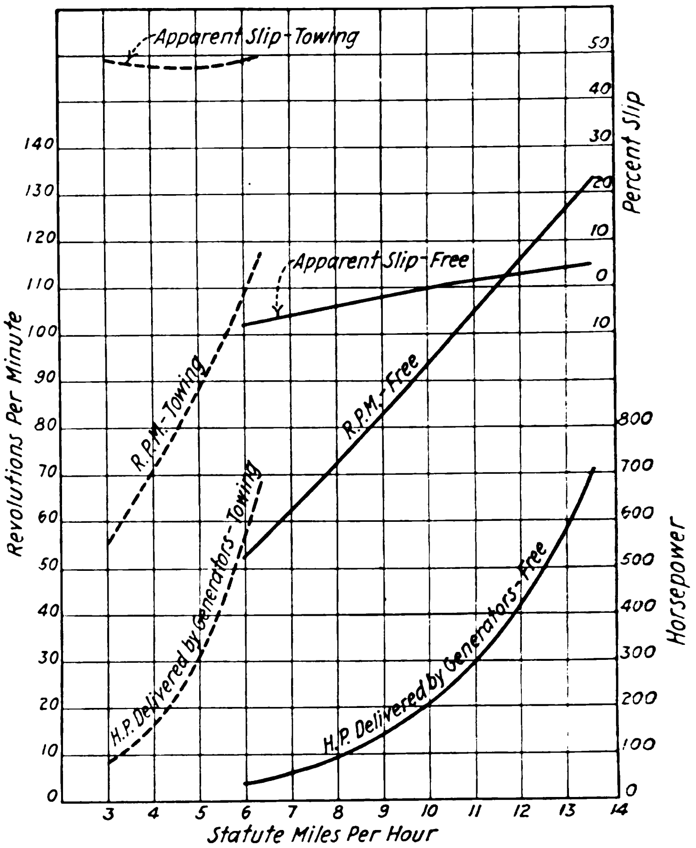


Fig. 9.—Chart Showing Horsepower, Revolutions of Screw Propeller and Apparent Slip of Tug P. R. R. No. 16 at Different Speeds, Towing and Running Free

tow line when towing being measured by a spring dynamometer. The instrument used is described in Vol. 4 of the Transactions of the Society of Naval Architects and Marine Engineers, "Speed Trials of a Screw Propelled Ferryboat."

The time required and the awkward navigation involved in running the tug with its tow over a measured mile course

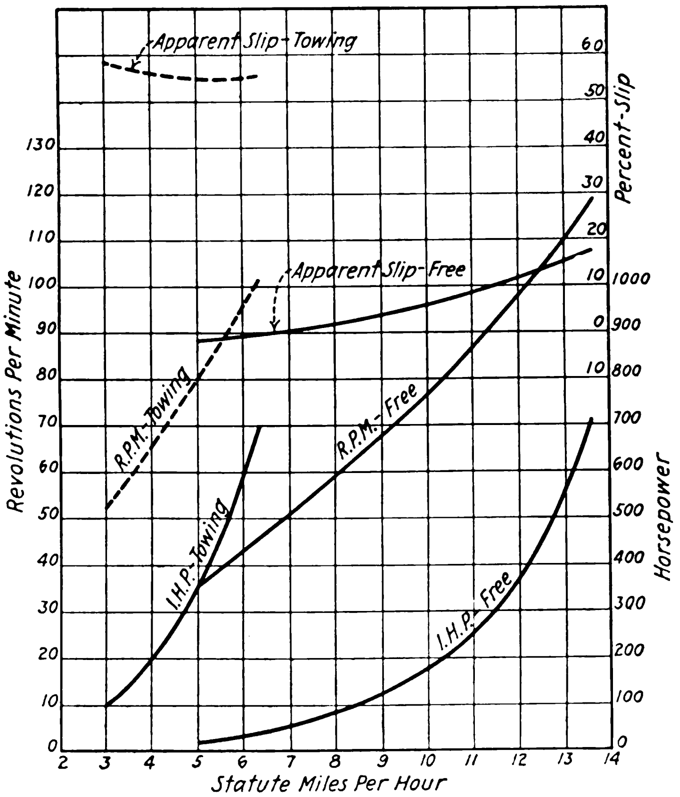


Fig. 8.—Chart Showing Horsepower, Revolutions of Screw Propeller and Apparent Slip of Tug P. R. R. No. 10 at Different Speeds, Towing and Running Free

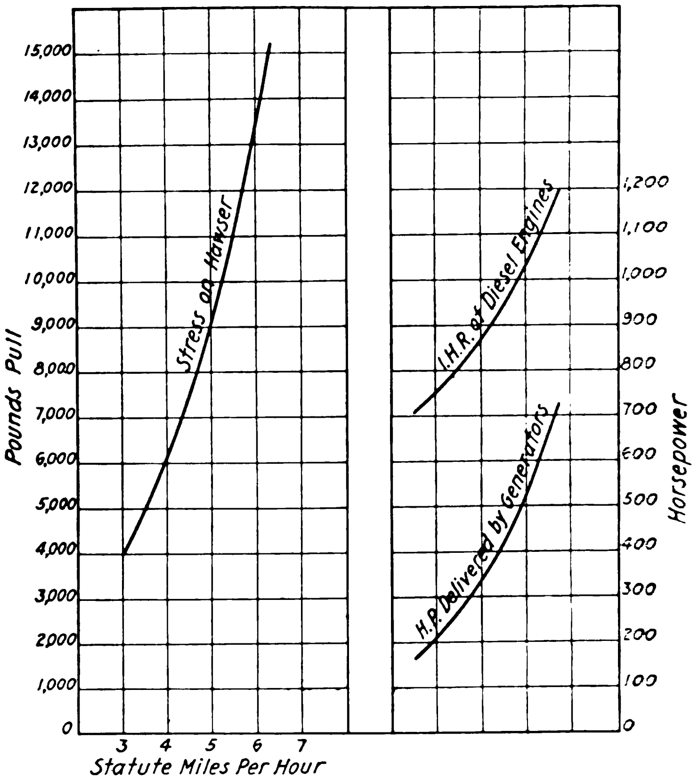


Fig. 10.—Towing Trials of Tug P. R. R. No. 16

Chart at left shows stress on tow line at progressive speeds. Chart at right shows relation between indicated horsepower of Diesel engines and power delivered by electric generators.

led to the use of a speed measuring device illustrated in Figs. 4 and 5. This, it will be noted, is a finished bronze screw immersed about 3 feet below the water level and about 7 feet forward of the stem of the tug, the revolutions of the screw being shown on a counter near the rail of the tug. This device was calibrated by running tug *P. R. R. No. 16* free on the measured mile twice in each direction at progressive speeds, and the factor of relative revolutions was found to be constant at the various speeds. This instrument was, therefore, used in all subsequent trials, avoiding the necessity for using the measured mile course.

The tow consisted of two steel car floats loaded and lashed abreast of each other, followed by a tug towed astern. The car floats are rectangular in form, built of steel, with rounded bilges and spoon-shaped ends, 250 feet long, 34 feet beam and 9 feet depth, as shown in Fig. 6, and each was loaded with ten cars of coal. The displacement of the floats and tug combined was 2,885 gross tons. The floats were towed by two hawsers, bridle fashion, each being 300 feet long, and the bight was led through a shackle on the dynamometer. Two floats towed in this fashion on a hawser will yaw to such a degree that the tow cannot proceed in a straight line, and the resistance will, therefore, vary considerably. It was necessary to tow a tug astern the floats whose rudder was used to maintain the tail end in a straight line. The tug did not aid in propulsion, and the tow was the heaviest the tug will ever be called upon to perform. The results of these trials are shown graphically in Figs. 7, 8, 9 and 10. The charts show the stress on the tow line at various speeds, also the relation between the indicated horsepower developed by the main engines and the power given out by the electric generators.

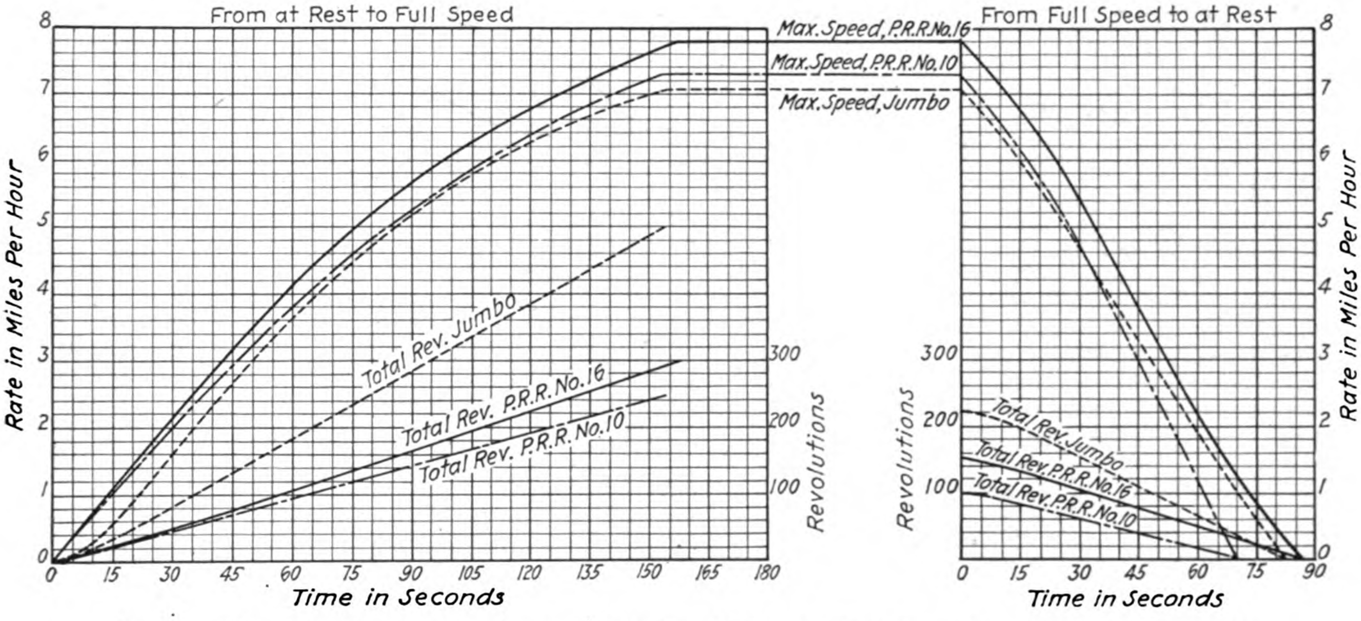


Fig. 11.—Chart Showing Accelerating and Retarding Ability of Tugs When Towing a Loaded Carfloat

While maneuvering, time can be saved and some collisions avoided if a tug can accelerate and also retard her speed quickly. To determine this feature trials were made with the three tugs, towing and running free. The tow was a carfloat loaded with ten cars of coal, the displacement being 1,260 tons. The tugs towed alongside as they always do, and the speed counter was fitted on the bow of the carfloat; observations were made every five seconds.

MANEUVERING TRIALS

With the tow the *Jumbo* reached a maximum speed of 7.08 miles in two minutes and thirty-five seconds. *P. R. R. No. 10* reached a maximum speed of 7.3 miles in two minutes and thirty-three seconds, and *P. R. R. No. 16* a maximum speed of 7.8 miles in two minutes and thirty-seven seconds. *P. R. R. No. 10* reached the *Jumbo* speed in two minutes and twenty-four seconds, and *P. R. R. No. 16* in two minutes and ten seconds.

MAXIMUM SPEED RUNNING FREE

Name	Rev. of screw per minute	Speed, statute miles per hour	I. H.P., total	H. P. output generators	Estimated shaft H. P.
Jumbo	202	12.28	643	......	502
P. R. R. No. 10	118	13.60	715	......	643
P. R. R. No. 16	133	13.52	1,175	702	646
**P. R. R. No.* 16	115	12.82	1,207	748	688

*When fitted with original wheel.

MAXIMUM SPEED TOWING

Name	Rev. of screw per minute	Stress on tow line, pounds	Speed, stature miles per hour	I. H.P. total	H. P. output generators	Estimated shaft H.P.
Jumbo	201	13,160	5.95	823	....	642
P. R. R. No 10	101.4	15,100	6.34	698	....	628
P. R. R. No. 16	117	15,180	6.36	1,163	684	629
**P. R. R. No.* 16	102	14,450	6.22	1,208	742	683

*When fitted with original wheel.

Retarding, the *Jumbo* brought the tow to rest from maximum speed in one minute and twenty-three seconds, *P. R. R. No. 10* in one minute and eleven seconds, and *P. R. R. No. 16* in one minute and twenty-seven seconds. From the *Jumbo* speed the *P. R. R. No. 10* brought the tow to rest in one minute and seven seconds and *P. R. R. No. 16* in one minute and sixteen seconds.

A graphic illustration of these trials is shown in Fig. 11, from which it will be observed that the straight Diesel drive with its small diameter wheel, as on the *Jumbo,* does not start the tow as quickly as the Diesel electric with its larger diameter wheel, as on *P. R. R. No. 16.* With the *Jumbo* the tow attained a speed of 0.6 mile in fifteen seconds, while with *P. R. R. No. 16* the tow attained a speed of 1.1 miles in the same time. This, again, is important in maneuvering.

Running free, the *Jumbo* from a speed of 12.28 miles came to rest in fifty seconds. *P. R. R. No. 10* from a speed of 13.60 miles came to rest in thirty-five seconds, and *P. R. R. No. 16* from a speed of 13.52 miles in twenty-seven seconds.

These tests are interesting, and, as far as I know, they are the first to be published.

Tug *P. R. R. No. 16* was originally fitted with a cast iron

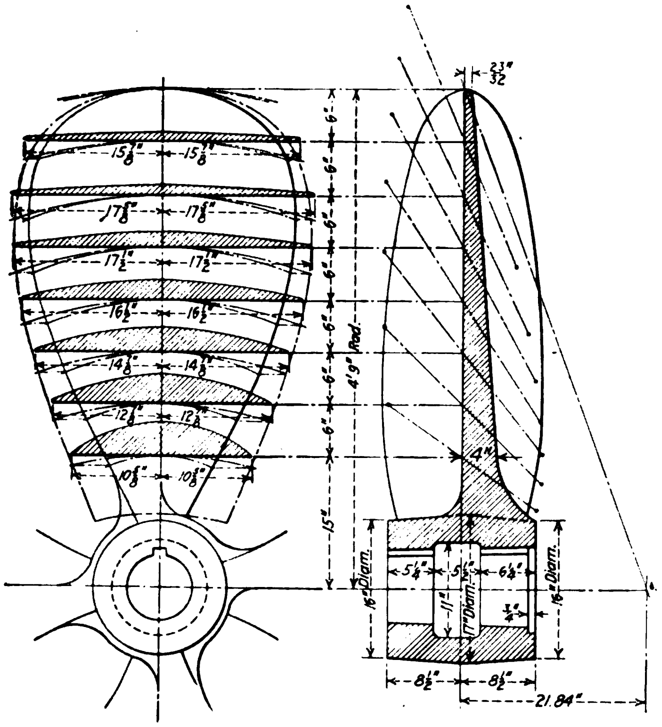


Fig. 12.—Original Wheel of P. R. R. No. 16

Four-bladed cast iron; diameter, 9.5 feet; pitch, 11.43 feet; disk area, 70.9 square feet; developed area, 38.1 square feet; projected area, 31.4 square feet; developed area ÷ disk area = 0.537; projected area ÷ disk area = 0.443; pitch ÷ diameter = 1.20.

wheel, 9 feet 6 inches diameter, 11 feet 5 inches pitch. This absorbed so much power that the propelling motor could not be operated within the limits of its designed speed of rotation, and a new wheel was made and fitted. The characteristics of the original propeller wheel and the wheel used on the *Jumbo* are shown in Figs. 12 and 13. The propeller now on the boat and that on the steam tug are shown in Figs. 14 and 15.

It will be noted that the engines, generators and motor on *P. R. R. No. 16* exceeded the guarantee of 575 shaft horsepower. The indicated horsepower of the Diesel engines shown on the charts is the result of our observation, and is shown as a matter of record only. Many people doubt the accuracy of indicator cards taken from the cylinders of Diesel engines as representing the power therein. I have my doubts

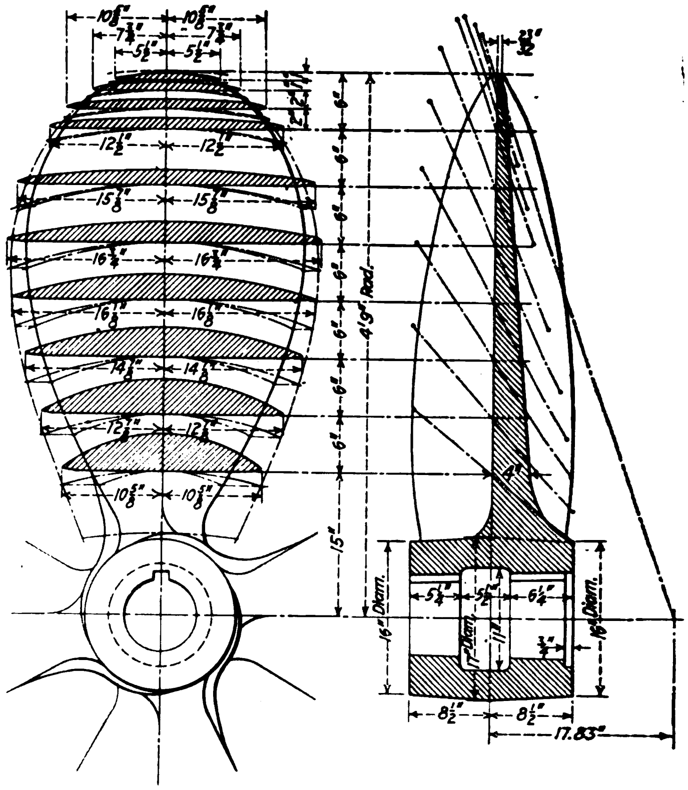


Fig. 14.—Propeller of Tug P. R. R. No. 16

Four-bladed cast iron; diameter, 9.5 feet; pitch, 9.33 feet; disk area, 70.9 square feet; developed area, 36 square feet; projected area, 30.4 square feet; developed area ÷ disk area = 0.508; projected area ÷ disk area = 0.429; pitch ÷ diameter = 0.983.

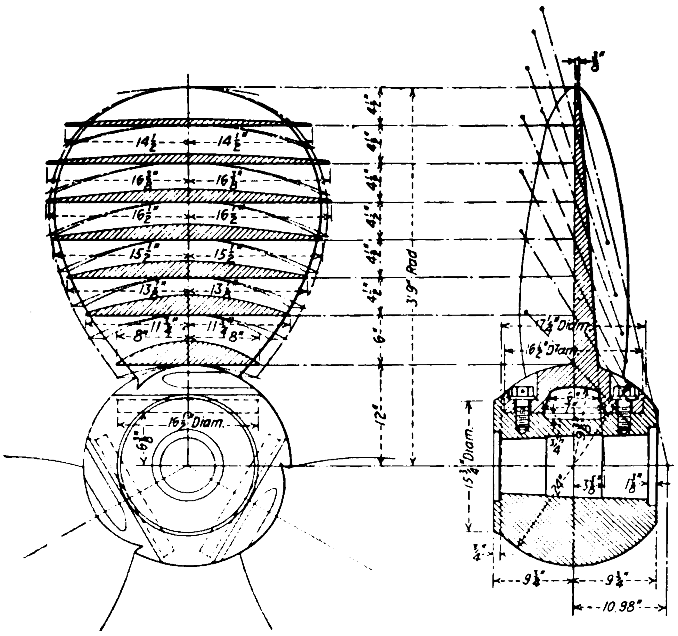


Fig. 13.—Propeller of Tug Jumbo

Three-bladed bronze; diameter, 7.5 feet; pitch, 5.75 feet; disk area, 44.2 square feet; developed area, 19.0 square feet; projected area, 17.7 square feet; developed area ÷ disk area = 0.43; projected area ÷ disk area = 0.4; pitch ÷ diameter = 0.767.

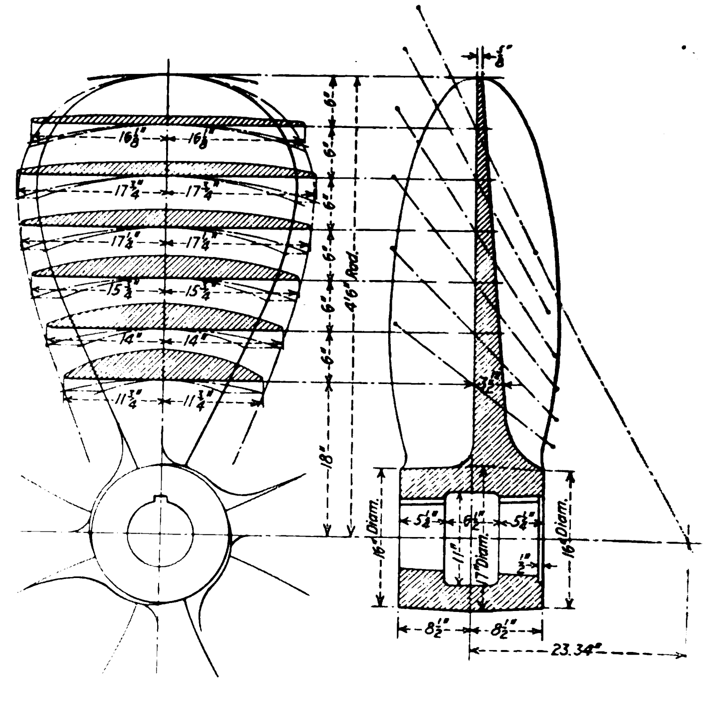


Fig. 15.—Propeller of Tug P. R. R. No. 10

Four-bladed cast steel; diameter, 9 feet; pitch, 12.22 feet; disk area, 63.6 square feet; developed area, 36.3 square feet; projected area, 27.9 square feet; developed area ÷ disk area = 0.571; projected area ÷ disk area = 0.438; pitch ÷ diameter = 1.36.

of their accuracy because all cylinders do not at all times produce the same power, a very slight variation in the oil or air injection affecting the mean pressure, and to obtain accuracy cards should be taken frequently and simultaneously from all cylinders, which, while possible, would be very troublesome. Again the indicated horsepower shown on the charts cannot correctly be related to and compared with the work done by the screw propeller. On the Diesel electric tug the main engines not only furnished power for their auxiliaries, but, through the excitors, power wherever used for other purposes on the boat. The straight Diesel tug furnished power for its engine auxiliaries only, and on the steam-driven tug the main engine furnished power for propulsion only, all auxiliaries being independently driven.

The work done by the screw should, of course, be compared with the power delivered to it. On the Diesel electric tug this can be determined with a reasonable degree of accuracy, the power output of the generator and the mechanical efficiency of the motor being known (91.9 percent). In the absence of direct determination, the shaft horsepower of the steam engine driven tug is estimated at 90 percent of the indicated horsepower. The shaft horsepower of the Diesel engine in the *Jumbo* is taken at 78 percent of the indicated horsepower, this being the reported results of shop tests by the New London Ship & Engine Company, by whom the engine was built.

The power used on tug *P. R. R. No. 16* for other than propulsion could be ascertained but was not necessary on these trials because the important feature, the amount of power delivered to the screw, was known by observation of the power used by the motor.

Results of Trials

The above data and the accompanying charts show:

That the Diesel electric tug has similar power to the steam-driven tug.

The advantages accruing with an improvement in the design of the propeller, the present wheel producing a greater speed and a greater tow-line stress with a smaller amount of power.

That the fast turning, relatively small diameter wheel required with the straight Diesel drive is not as efficient as the larger diameter wheel driven at a more appropriate speed.

The charts recording the trials will show that the maximum speed, 12.28 miles, obtained by the *Jumbo* running free could be obtained by the *P. R. R. No. 16* with 76 less horsepower on the propeller shaft, and that the maximum tow-line stress obtained by the *Jumbo*, 13,160 pounds, could be obtained by *P. R. R. No. 16* with 134 less horsepower. This is interesting, showing, as it does, that the straight Diesel drive requires 15 percent more power on its propeller shaft on a tug running free and 26 percent more power when towing than the Diesel electric, due, it would appear, to the characteristics necessary in the design of the wheel. The losses due to the use of generators and a motor between the Diesel engine and the propeller shaft at maximum power are 16 percent, equivalent to 18 percent increase in power on the basis compared above. This suggests that there is a large field for experiment in the design of propeller wheels for tugboats equipped with the straight Diesel drive. Very little has been done in this direction, and designers have very little, if any, data from which to reach conclusions, for they must work far below what experimenters consider efficient minimum pitch ratios, and ignore much that has been said as to the advantage of large blade areas for tugboats in order to produce wheels of large enough diameter for tug boat work.

It will further be observed that on the steam tug, when towing, the stress on the tow-line absorbed 40 percent of the power delivered to the screw, on the Diesel electric, 41 percent, and on the straight Diesel, 32 percent. These figures do not represent the efficiency of the tugboat wheels, as the resistance of the tugboat should be included in the work done by the wheel, but as all of these tugs are of approximately the same displacement, the figures are comparable.

It will be noted that the steam tug and the Diesel electric tugs are of similar power. The weight of the devices required to produce this power is as follows:

Tug *P. R. R. No.* 10 (steam)	Tons
Weight of main engine, pumps, condenser, shafting and propeller	30
Weight of boiler (Scotch type), stack, pumps, piping and valves	72
Weight of coal and water, including bunkers and tanks, 3½ days' supply	75
Total	177

Tug *P. R. R. No.* 16 (Diesel electric)	Tons
Weight of main engines and attached auxiliaries, air bottles, muffler, shafting and propeller and stack	79
Weight of electric generators, motor, switchboard and wiring.	47
Weight of fuel and lubricating oils, including tanks for 7 days' supply	32
Increased weight of foundation.	7
Total	165

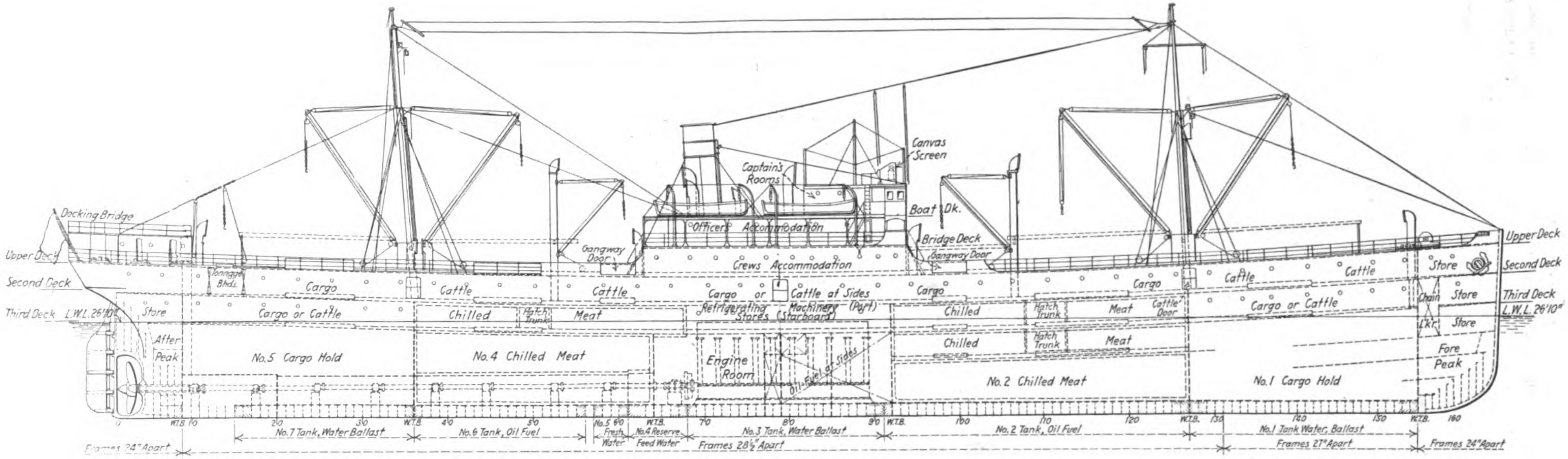
Note: Substituting a B. & W. watertube boiler for Scotch type reduces weight 30 tons.

In connection with the relative economy of the three types of tugboats, we have no data bearing on the original cost and the operating cost of the straight Diesel tug. The original cost of a Diesel electric tug like *P. R. R. No. 16* is about 20 percent higher than a steam-driven tug similar to *P. R. R. No. 10*. The Diesel electric is operated with one man less in the crew and the fuel costs are less: Tug *P. R. R. No. 16* uses 214 gallons of oil in eight hours, which at 5 cents per gallon costs $10.70. Lubrication of a Diesel engine is extravagant and swells the above cost to $12.96. The steam-driven tug, *P. R. R. No. 10*, used 3.58 tons of bituminous coal in eight hours, which at $6.50 per ton costs $23.27. The cost for lubrication is 18 cents, or a total of $23.45. After equating the additional investment in the Diesel tug through the various overhead expenses, such as taxes, interest, depreciation, insurance and maintenance, and balancing this with the saving in direct operating expenses, there appears to be a saving of 24 percent in the total yearly expense of the Diesel electric tug as compared with the steam-driven tug. The relative cost of fuel will vary this economy. The costs given are the commercial prices in this harbor for October, this year.

Experience with the Diesel electric tug in service shows several operating advantages, some of which were anticipated. The advantage of pilot-house control and maneuvering at any speed has been described. The boat can advance toward a pier or vessel slowly or quickly, in fact in any desired speed with an accuracy that permits perfect maneuvering. Severe contact and attendant damage are avoided. In picking up a tow the boat can proceed at appropriate speeds so as to avoid excessive strains on the towing lines. Full power is always available which in intermittent work is valuable, and there is no delay caused by condition of fires, quality of coal, and efficiency of firemen as on a steam tug.

Using one engine only, a free speed of 11.25 miles was obtained, and with the tow previously described, a speed of 5.10 miles with a tow-line stress of 9,200 pounds was obtained. A considerable amount of the drill work is, therefore, performed with the power produced by one engine, with a resulting fuel economy. On a steam tug time is required to take on coal, remove ashes and take on water. The average time for these combined is two hours in twenty-four. On the Diesel electric less than two hours in a week is needed to take on the oil supply. Therefore more work is obtained from the investment.

There is less physical work required by the machinery forces, and a better grade of men is attracted thereto. The navigators are all pleased with the personal ability to control the propeller, and mistaken signals are avoided. The movement of one lever in the direction the boat is to proceed is less arduous than pulling bell signals, and there is less to think about. When an appropriate speed is selected, the boat steers sternward as accurately as ahead.


Docking Bridge
Upper Deck
Second Deck
Third Deck
L.W.L. 26'10"
Store
After Peak
Tonnage Bhds.
Cargo
Cargo or Cattle
No.5 Cargo Hold
Cattle
Chilled
Hatch Trunk
Meat
No.4 Chilled Meat
Gangway Door
Cattle
Officers' Accommodation
Captain's Rooms
Crews Accommodation
Cargo or Cattle at Sides
Refrigerating Machinery (Port)
Stores (Starboard)
Engine Room
Oil Fuel at Sides
Canvas Screen
Boat Dk.
Bridge Deck
Gangway Door
Cargo
Chilled
Chilled
Hatch Trunk
Hatch Trunk
Meat
Meat
Cattle Door
No.2 Chilled Meat
Cargo
Cattle
Cargo or Cattle
No.1 Cargo Hold
Cattle
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Store
Store
Fore Peak
Upper Deck
Second Deck
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L.W.L. 26'10"
0
W.T.B. 10
20
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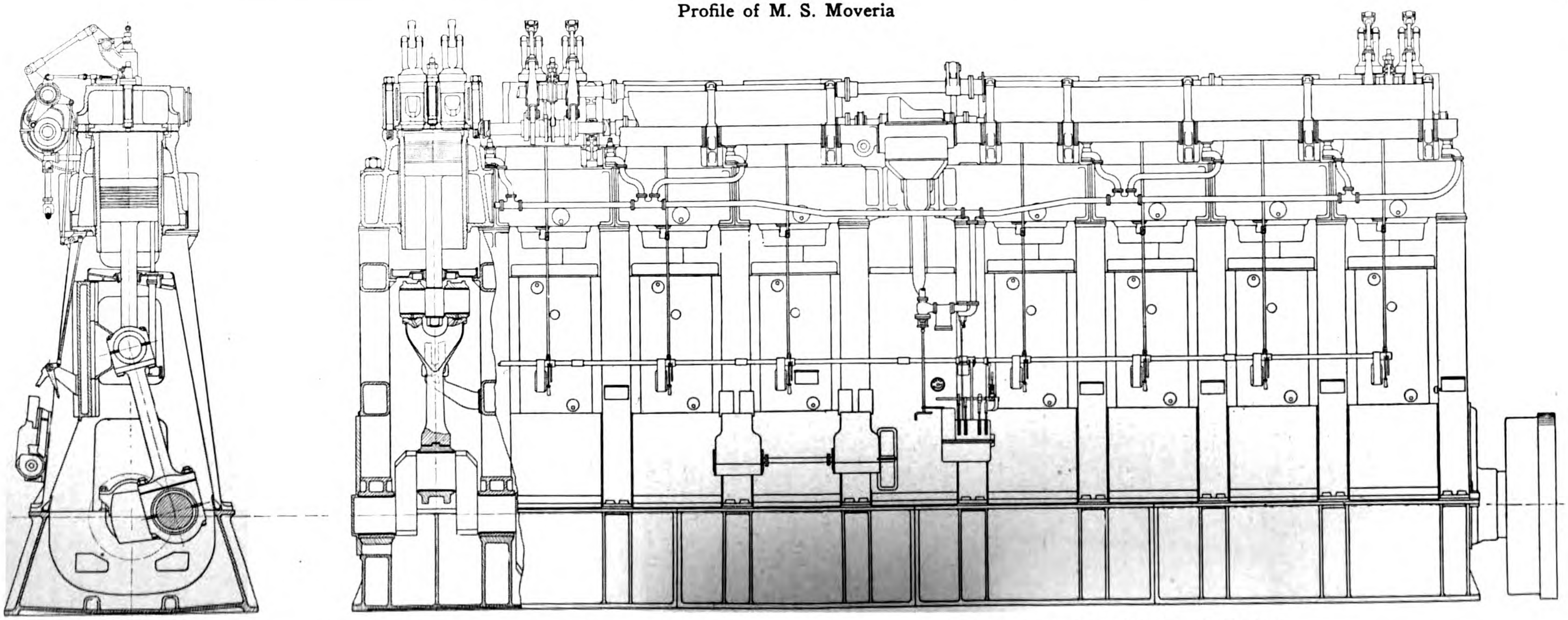
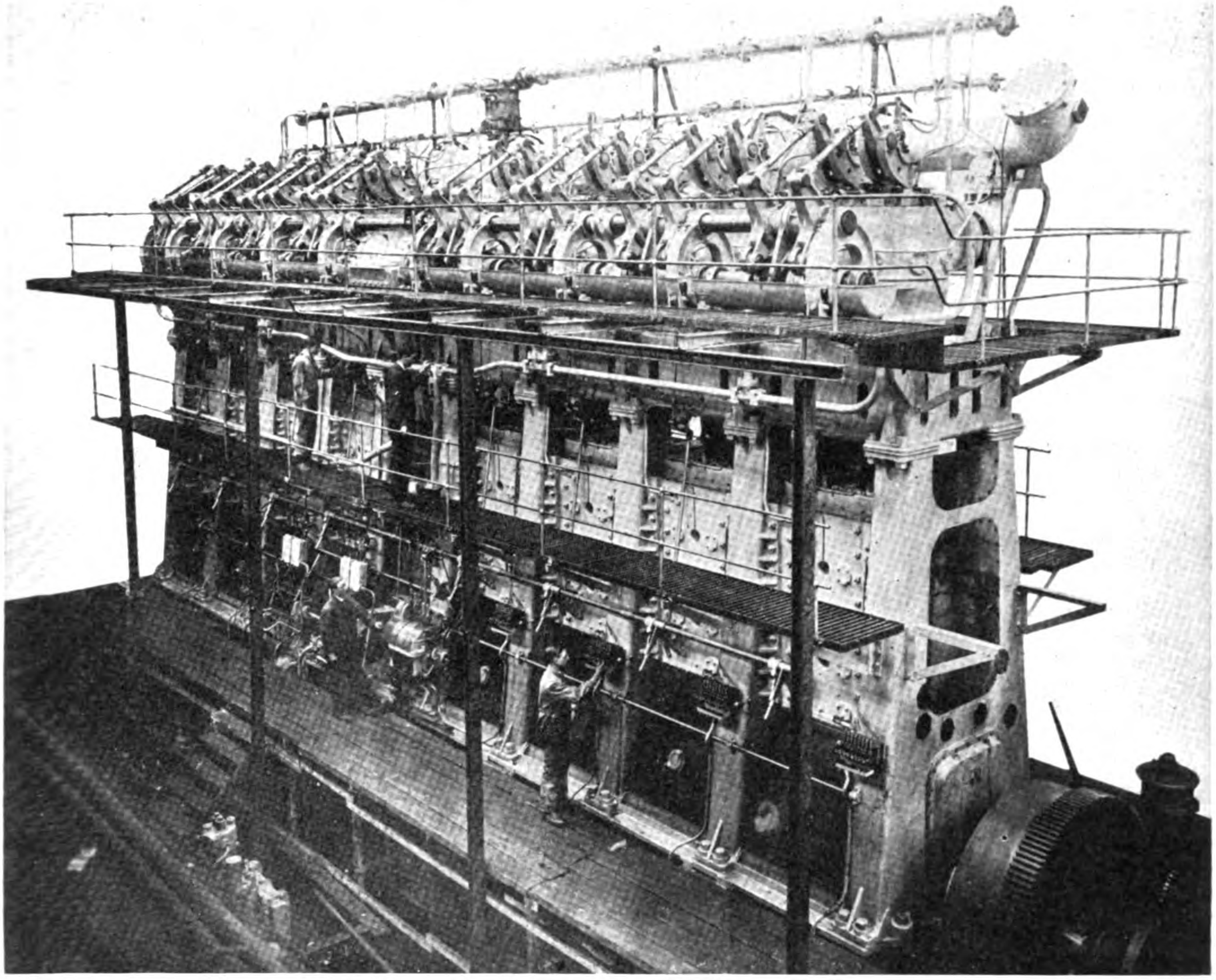
W.T.B.
40
50
No.5 60
W.T.B.
70
80
90 W.T.B.
100
110
120
W.T.B. 130
140
150
W.T.B.
160
No.7 Tank, Water Ballast
No.6 Tank, Oil Fuel
Fresh Water
No.4 Reserve Feed Water
No.3 Tank, Water Ballast
No.2 Tank, Oil Fuel
No.1 Tank Water, Ballast
Frames 24" Apart
Frames 28½" Apart
Frames 27" Apart
Frames 24" Apart

Profile of M. S. Moveria



Vickers 2,700 Brake Horsepower, 8-Cylinder Engine; Diameter of Cylinders, 30 Inches; Stroke, 45 Inches



Vickers Solid Injection Engine of 3,500 Indicated Horsepower Installed on M. S. Moveria

Vickers Diesel Engine of 3,500 I.H.P. Installed on Single Screw Vessel for North Atlantic Service

By Our Special London Correspondent

IT will not have escaped the notice of those who are closely watching the shipping situation that, in spite of the admittedly rapid development of the oil-engined vessel, practically no motorships are being built for service across the North Atlantic. The reason is, as Sir Frederick Lewis (chairman of Furness, Withy and Company, and Manchester Liners, Ltd.) remarked recently, when stating that two fast steamers would be built for the latter concern, the motor vessel shows to greatest advantage on long voyages and not on the comparatively short Atlantic route.

All shipowners, however, do not share Sir Frederick Lewis's views, as is instanced by the fact that a very interesting type of motor cargo carrier has just been launched from Vickers' Barrow yard for the Donaldson Line, for service between England and North American ports. The new vessel is noteworthy from the standpoint of both the engineer and shipbuilder. She is built on a new system of double bottom construction which gives easy accessibility to piping and, it is said, reduces the weight of steel necessary in the construction, thus lowering the cost.

THE LARGEST FOUR CYCLE SINGLE ACTING ENGINE YET BUILT

In these days of the rapid development and increasing application of two stroke, single acting and of double acting Diesel engines, it is sometimes forgotten that builders of four stroke, single acting machinery have by no means given up the struggle. Thus in the *Moveria*, as the new Donaldson liner is named, the highest powered Vickers solid injection engine—of 3,500 indicated horsepower—is to be installed, and, moreover, this motor has the distinction of being the biggest plant of the four cycle, single acting class yet built. Its output is approximately equal to that required in the conversion of some of the Shipping Board's vessels, and from this standpoint it is of interest to view it in relation to the designs that will be utilized for this purpose.

It has eight cylinders, 30 inches in diameter with a stroke of 45 inches and runs at 110 revolutions per minute, which is perhaps slightly on the high side for a single screw vessel of 11 to 12 knots speed. It differs in appearance from most normal Diesel engines in the absence of an injection air compressor, since, as is well-known, in the Vickers system, solid injection of fuel is employed.

The pressure utilized for this purpose is 4,000 pounds per square inch, compared with 8,000 to 9,000 pounds per square inch with the Doxford system. In the latter, there is one large pump driven by spur gearing off the end of the crankshaft, delivering the fuel to a distribution box whence it is supplied to the separate cylinders. In the Vickers arrangement, there are two groups of pumps, each with four plungers, driven by an eccentric off a layshaft, itself driven by spur gearing from the crankshaft. These pumps do not supply the oil direct to each separate cylinder, but to a common main with a pipe leading to each fuel valve.

The cylinders are cast with feet and they are supported on flanges at the top of cast iron columns, the bases of the cylinders being bolted together. Vertical steel columns are employed for taking the main stresses, these being housed within the hollow cast iron frames, and it will be noted that there is a substantial space between the bottom of the cylinders and the top of the crankcase. The latter is covered by a diaphragm for each cylinder, the main object of which is to prevent any used lubricating oil dropping down into the sump, or for any water from the telescopic piston cooling pipes falling and contaminating the lubricating oil below.

METHOD OF COOLING

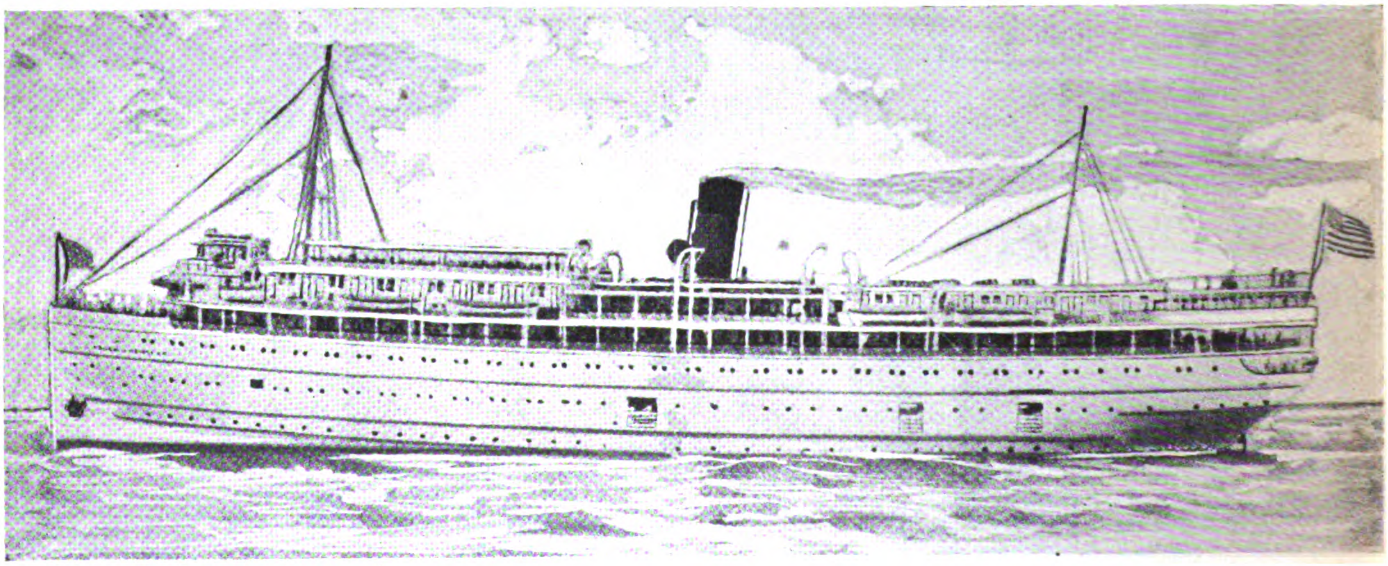
The cooling of the cylinder jackets, the cylinder heads, the exhaust valves and the pistons is effected by salt water; the engine drives two separate pumps, one for the piston cooling water and the other for the remainder of the engine. The reason for this is that the pressure in the piston cooling system is somewhat in excess of that needed for circulating the water through the cylinders. The method of delivering the cooling water to the exhaust valves and discharging it is peculiar as armored hose pipe is utilized. It will be gathered from the illustration that levers operating the valves are pivoted on a horizontal shaft located above the camshaft. By partially rotating this upper spindle, the cams are lifted off the camshaft before the latter is moved fore and aft, during the course of the reversing operation.

It will perhaps come as a surprise to those who are not accustomed to Diesel machinery, to learn that the total length of this engine from the after end bearing to the end of the flywheel is in the neighborhood of 50 feet, while the height above floor level is over 20 feet, and the maximum width between 9 and 10 feet. Naturally, a two stroke, single acting engine would show to considerable advantage in this respect, and a double acting type would be still more favorable. In comparison, it may be mentioned that Doxford opposed piston and North British double acting, two stroke engines of the same output are both being built as standard models, with only four cylinders. But it is only fair to add that there are other considerations involved, beyond the size and weight of an internal combustion motor.

AUXILIARY MACHINERY

British shipowners ordering motor vessels are showing a marked preference for steam driven auxiliary machinery, mainly on account of the saving effected in capital outlay, which is usually in the neighborhood of £2 per ton deadweight. Steam auxiliaries are fitted in the *Moveria* and three comparatively large boilers are installed in the engine room. There are two auxiliary compressors for the supply of compressed air for starting and maneuvering purposes, and the usual engine room pumps are coupled to steam engines, apart from the circulating pumps which, as previously mentioned, are driven off the propelling engine, together with a lubricating oil pump and a bilge pump. On deck are fourteen steam driven winches and steam steering gear and as the insulated chambers have a capacity of 170,000 cubic feet, a large CO_2 refrigerating plant (also steam driven) is installed.

The *Moveria* is 398 feet in length overall, or 385 feet between perpendiculars, has a molded beam of 51 feet 6 inches, and a depth to the shelter deck of 39 feet. The loaded draft is about 26 feet 9 inches, and the deadweight capacity is 7,500 tons. Nine hundred tons of fuel can be carried in the double bottoms, or two side tanks. Provision is made for carrying 600 live cattle and general cargo can, of course, also be accommodated.



Steamship South American as she will appear when reconditioned after heavy fire damage. The vessel is owned by the Chicago, Duluth & Georgian Bay Transit Company, and the contract is being carried out by the Manitowoc Shipbuilding Company at a cost of several hundred thousand dollars.

The Design and Construction of Refrigerated Ships*

Insulation and Refrigerating Machinery Requirements of Fruit, Frozen Meat, Chilled Meat and General Refrigerated Cargo Carriers

By Llewellyn Williams

THE successful commercial operation of a refrigerated carrier depends: First, on the satisfactory operation of the refrigerating machinery equipment with proper carriage of the refrigerated cargoes, and, second, on the vessel's maintaining an economic speed for the trade in which it is engaged. The economic speed for a refrigerated carrier in any particular trade would seem to be somewhat different from the economic speed of a non-refrigerated cargo carrier in the same trade, because the capital expenditure on the refrigerated carrier would probably exceed that on the non-refrigerated carrier by 40 percent, and this increased cost would require a higher sea speed with rapid turn round in port to produce an equal earning capacity per unit of capital invested, unless the extra compensation is to be made up entirely by a higher freight rate.

A refrigerated carrier will have a smaller deadweight capacity than a similar non-refrigerated carrier in addition to its higher capital cost, and if the lesser deadweight be not compensated for by higher speed with more cargoes handled per unit of time than the non-refrigerated carrier, the extra capital burden must be entirely covered by a higher freight rate.

The capital expenditure necessary to properly install insulation and refrigerating machinery equipment in a vessel depends very largely upon the design of the hull. If the steel work be designed to receive insulation in an economic manner, the cost of the insulation and the refrigerating machinery equipment will be materially reduced and the final efficiency greatly improved.

Refrigerated cargo does not consist of large packages. Therefore a refrigerated vessel designed to deal only with refrigerated cargo would not require large hatchways, but the necessities of rapid loading and discharging could best be served by a number of small hatchways so placed as to minimize cargo handling and suitable for multiple operation.

Unfortunately, refrigerated cargoes are usually carried in one direction only, and the vessel's design, particularly as to hatchways, has to be suitable for general cargo on the opposite voyage.

Refrigerated carriers are generally special vessels, designed and constructed for the trades they are to fill. Vessels, while very similar in general design, will materially differ in fuel capacity if not in economic speed. Again, vessels constructed to carry citrus fruits, vegetables and apples from Pacific Coast ports to Atlantic ports, or vessels similarly constructed to carry these same products to European ports, would be similar as to refrigerating requirements but different as to economic speeds and fuel capacity. Generally speaking, a satisfactory banana carrier would be a satisfactory vessel to carry citrus fruits from west coast points to the Atlantic seaboard, except that the economic speed and cargo capacity of the banana carrier would be much lower than those for a satisfactory west to east coast fruit carrier, although the characteristics of the refrigerating equipment would be similar in each case. A vessel constructed to carry frozen meat cargoes throughout would not be suitable for a chilled meat cargo, nor would it be suitable for the carriage of anything but a frozen cargo, though not necessarily of frozen meat. Further, a vessel suitably constructed to carry a mixed frozen and chilled meat cargo would not be entirely desirable for the carriage of general cargoes including case goods, such as apples, which require ventilation. These individual special trades, to be cared for economically, require tonnage designed and constructed for their special requirements.

The difference in refrigerating machinery equipment between fruit carriers, frozen meat carriers, chilled meat carriers, and general cargo carriers may be briefly stated as follows:

Fruit carriers should be fitted with cooling equipment operating on the forced indirect air circulation system with ample provision for external ventilation, as the satisfactory carriage of the cargo depends almost as much on ventilation as refrigeration. A banana cargo is loaded in bulk and not dunnaged, but is divided by bins.

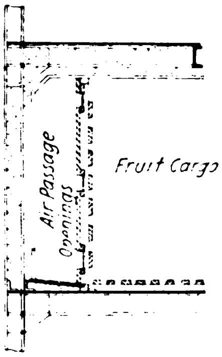


Fig. 1

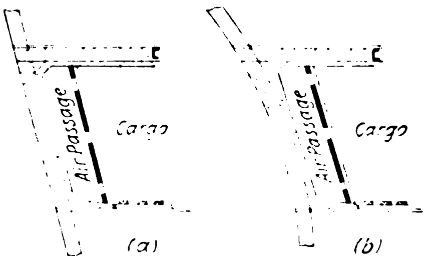


Fig. 2

Air duct for fruit ship.

Frozen meat carriers require no ventilation in service but have to be heavily insulated for the low temperatures necessary, and can be, comparatively speaking, lightly piped on the bulkheads, sides and under ceiling with brine cooling pipes, cooling being by direct radiation from these pipes. The cargo is loaded in bulk suitably dunnaged for natural air circulation.

A chilled meat carrier requires to be designed with certain heights in the cargo spaces and very heavily piped with the piping under the ceilings, so arranged that the economic distribution of the meat-carrying rails will not be interfered with by the arrangement of the piping or the particular design adopted in the vessel's steel work to be insulated. This cargo must all be carried suspended from overhead rails, and therefore the steel structure of the decks requires special attention for the loads to be carried. The cooling system requires to be very carefully arranged by skilled designers in order to procure the fine temperature adjustments necessary for the carriage of chilled beef, particularly on long voyages where temperature variations of more than half a degree in the cargo spaces are not allowed.

The general refrigerated cargo carrier would require certain spaces such as deep holds suitable for the carriage of frozen goods in particular, with 'tween-deck spaces suitable for the carriage of chilled meat or case goods, and with other 'tween-deck spaces arranged with air circulation for the carriage of fruit. This type of carrier might be considered as a combination of the first three in parts, and is the usual type of vessel which should be considered for general refrigerated trades as the nearest type of vessel which can care for any refrigerated cargo.

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*Paper read before the Society of Naval Architects and Marine Engineers, New York, November, 1924.

Fruit Carriers

In a fruit carrier the air circulation system of cooling is generally carried out by means of air ducts (Fig. 1) carried fore and aft along the vessel's sides and connected to a battery of air-cooling pipes with air blowers at the bulkheads. So that there may be no undue air resistance, it is important that the insulation surface be as little broken as possible, and therefore deep beams, web frames or extra deep brackets should be avoided where possible in 'tween decks, and stringers or panting beams in holds made shallow to present the least amount of resistance. Decks laid flat with no camber would be an advantage, and lines (Fig. 2a) giving straight shell plating would materially benefit insulation and stowage as compared with lines (Fig. 2b) giving hollow curved sections, particularly as it is necessary for the operator to walk through the air duct passages.

The air currents through the cargo are in a thwartship direction, and any obstructions extending far below the line of the insulated ceiling, and themselves insulated, are detrimental, as they form hot air pockets where they block the circulation. It is therefore desirable to use shallow fore and aft girders with closely spaced circular stanchions instead of deep girders and widely spaced, built-up pillars. For the same reason the hatch coamings should be made to extend as little as possible below the beams or above the decks, and if the fore and aft girders line up with the hatch coamings the stanchions will be in the proper position to support the wooden bins necessary to separate the cargo and prevent settlement, called "fruit fittings."

Decks are insulated on the under side throughout or, as a margin insulation only in case of dividing decks, and according to the particular requirements of the trade. All winch bedplate stiffeners should be above the deck rather than below, with as few stanchions as feasible unless these can come in line with the requirements of the fruit bins, which they will then help to support; otherwise they tend to break stowage, have to be separately boxed, and are a source of expense and annoyance. Deck heights of 7 feet below beams is sufficient for uninsulated decks and 7 feet 3 inches for insulated decks, and hatchways 14 feet by 12 feet are large enough for handling the fruit cargo. The hatchways should be fitted with light, easily removable strongbacks carrying the usual pine or spruce hatch covers for uninsulated decks, and heavy enough to carry insulated hatch covers with superimposed white wood hatch covers for insulated decks. The insulated hatch covers do not carry the cargo weight or tarpaulins, these being carried by the ordinary white wood hatches. As it is necessary to remove all hatch covers at every loading and discharging and rapid handling is a necessity of the trade, special care should be given to the design of these parts to effect this purpose.

The air-cooling batteries and blowers must be so placed that they can be readily accessible at all times to the operating engineers and officers for the purpose of regulation, logging air temperatures, and examination of the cargo. In addition, convenient ventilators for fresh air inlet and foul air outlet must be fitted for each air cooler battery. These requirements usually govern the position and arrangement of the air-cooling batteries and their blowers in reference to the superimposed cabin or other construction.

Citrus fruit cargoes pack at approximately 75 cubic feet to the long ton, and the cargo is loaded in packages as it comes from the packing houses. The cargo should be precooled at a shore plant before being loaded into the vessel and the vessel's chambers cooled to a temperature slightly lower than that required for the carriage of the cargo prior to commencing loading. The work to be performed by the refrigerating equipment, therefore, consists of taking up the heat leakage through the insulation, and also the heat given off by the cargo, and, in addition, to cool and humidify the air introduced for ventilating the cargo.

The cargo should be raised off the deck by dunnage battens or gratings, giving at least 3 inches of air space, with 2 inches dunnage battens on all flat vertical surfaces, such as air ducts along the sides, bulkheads, ventilators, or similar parts, to insure a thoroughly satisfactory air circulation; in addition each alternate row of cases should be arranged with dunnage battens between them so as to insure air circulation throughout the bulk of the cargo.

In a 7-foot 'tween deck the deck load due to cargo insulation and gratings would be approximately 250 pounds per square foot.

In a banana carrier the deck gratings and battens are even more important than in a citrus fruit carrier, but the cargo is packed in bulk uncrated, the bunches being stacked standing vertically, usually 2 rows high, with one row lying flat above. The cargo packs about 150 cubic feet to the long ton. Under these conditions the deck load for a 7-foot 'tween deck would amount to approximately 150 pounds to the square foot, including the insulation and gratings. Bananas can be carried satisfactorily stored in bulk in holds the height of which is 10 feet, but if greater heights than these are necessary, there is a grave possibility that the cargo will become damaged by its own weight and the movement of the vessel, especially those bunches which may ripen and become soft. If the voyage is over ten days in duration, the cargoes should be stowed as lightly as possible and deep stowage avoided.

The insulation has to be suitable for a temperature of 50 degrees and provisions must be made for warming the cargo in cold weather, especially during the period of discharging in cold northern ports. The insulation must be on all external surfaces and on the margin plate of middle decks, but the entire insulation of middle decks depends largely on whether the vessel is to be loaded completely at one port so that it can be simultaneously cooled throughout, or whether it is to be loaded at two or more ports, in which case the middle decks should be insulated in their entirety and each insulated compartment dealt with by its own air cooler battery and independent air circulation system, as it would not be desirable to have warm fruit loaded into the air passing over fruit already cooled by the same air system.

The fruit is loaded directly as it comes from the plantations at normal atmospheric temperatures, and therefore the duty to be performed by the refrigerating machinery equipment consists of cooling the cargo as rapidly as possible to its safe carrying temperature of from 53 to 55 degrees and maintaining it at that temperature. The plant requires to be of very large power and approximately of three times the refrigerating capacity which would be required for a refrigerated fruit carrier for dealing with citrus or other fruits, which have been already pre-cooled by a shore equipment. It is, therefore, important that the refrigerating machinery, fans, air ducts, air passages and all parts of a banana vessel be proportioned to each other and of ample capacity for the work to be performed.

Chilled Meat Cargo

In the carriage of chilled meat, the entire cargo is to be suspended from the under side of the decks and no deck gratings are required. It is highly important that suitable deck heights be provided, as the meat shippers will only pay for that portion of the available space they can use for their cargo. This requires a height of 6 feet 6 inches below the meat rails in 'tween-deck spaces, and 9 feet 6 inches as the next most economical height for holds from the under side of the meat rail to the insulated deck surface, and increasing in 3-foot increments.

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Chilled meat cargoes have been sucessfully carried in holds with a height even as high as 15 feet 6 inches, but it is not recommended that this be done on account of the difficulty of stowage and handling the cargoes when suspended from these heights, as well as the possibility of poor air circulation through the meat. The cargo packs at about 125 cubic feet to the long ton, which would give deck weights of approximately 160 pounds per square foot of surface as applied to the under side of the deck for 'tween-deck heights of 6 feet 6 inches and more for deeper compartments, but inasmuch as the ship may be required to carry a general cargo or other refrigerated cargo supported on the upper side of the same deck, it is obvious that the decks must be designed for a total cargo weight aggregating not less than 400 pounds per square foot of surface for 'tween-deck heights. The temperatures at which chilled meat is to be carried are fixed by the shipper, who usually instructs the carrier in this matter, and the responsibility of the carrier depends upon his maintaining these temperatures within the limits of variation agreed upon.

It is essential that very even temperatures be maintained in chilled meat vessels, the variations usually allowed being not more than one-half degree throughout any compartment when loaded from a fixed temperature of 29 degrees F., although some shippers require the temperature lowered after a certain number of days of voyage have elapsed, by gradually reducing it to a specified minimum as the length of the voyage increases. Generally chilled meat cannot be successfully carried for over 35 days.

The refrigeration is performed by brine pipe coils, suspended from under the ceilings and on the sides and bulkheads of the refrigerator compartments, and particular care must be exercised in the arrangement of the overhead coils so as not to shut out any available meat rail accommodation, as this would mean lost cargo space and broken stowage; also the brine circulation through the coils has to be most carefully laid out by experienced designers in order to maintain the even temperatures required and protect the cargo against an involuntary shutting off of any one circuit of brine flow. The piping should be arranged on the so-called interlaced system, and there must be available a supply of cold brine, tepid brine and warm brine which can be used through each or any circuit so as to control the temperatures. If the vessel be fitted with insufficient piping, a brine colder than otherwise necessary must be used, resulting in cargo shrinkage, due to loss of weight with the formation of ice on the coils, and also uneven temperature.

It is most important that all openings be closed practically air tight so as to prevent the introduction of moisture from the outside air into the compartment with the resulting icing up of the pipes. Inasmuch as the meat has to be suspended by metal hooks from overhead suspending rails, it is most important that the supports for these rails be insulated from the vessel's steel work in such a way that external heat cannot travel down the supporting steel work to the rail and cause softening of the meat where it is suspended from the hook.

Bulkhead and side coils must be protected by wooden battens so that the meat cannot come in contact with the cold piping directly, and vertical surfaces not piped must be fitted with 2-inch dunnage battens about 12 inches apart to keep the cargo from pressing directly on the insulation and to insure an adequate natural air circulation about all parts of the meat cargo. The cargo is packed sufficiently tight together so as to prevent undue motion by swinging with the motion of the vessel and yet allow adequate air circulation between the several parts of suspended meat. If chilled meat is to be carried in 'tween-deck spaces above holds containing frozen cargo, the deck dividing the frozen and chilled compartment should be insulated on the upper as well as the lower surface, or the cold from the hold will strike through into the chilled space and damage the cargo.

Absolute cleanliness is essential for the proper handling of chilled cargoes, and therefore the finished surface of the woodwork should be made with rounded edges and free from fillets in which dirt may lodge, and so arranged that they can be sponged thoroughly clean and with suitable ventilation for drying out the compartment thoroughly before cooling down to load a refrigerated cargo. The wooden coil battens keeping the meat cargo away from the coil surfaces should be made readily portable so that they can be thoroughly cleaned and replaced, and so that the coils below them can also be cleaned and painted if necessary to keep them in a thoroughly sanitary condition.

Adequate scuppering is very essential, and the scuppers should be provided with traps placed in the bilge preventing freezing, and to prevent bilge air from rising to the chambers, and in addition should be furnished on their upper side with positive shut-off valves which should be kept closed when the cargo is loaded.

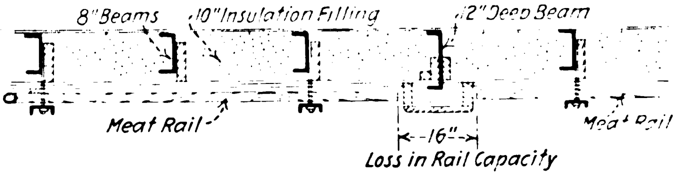

Fig. 3.—Sketch Illustrating Loss in Meat Rail Capacity Due to Use of a Deep Beam

The 'tween-deck heights necessary to provide 6 feet 6 inches from the under side of the meat rail, which will be approximately 3 inches below the insulation, and assuming 8-inch beams with 2½ inches of insulation filling below the beams contained by two ¾ T. & G. boards would give an overall insulation depth of 12 inches and a total molded deck height of 7 feet 9½ inches as the most economical stowage height for chilled meat carriers with 8-inch beams. Inasmuch as the object of the design is to obtain the maximum amount of meat rails under the ceiling, and as these rails should be placed fore and aft at 12-inch centers, it is obvious that the most economical design of steel work will be that which projects the least distance below the beam depths so as to present a plain insulated surface when complete. The beam-knees should be made as small as possible, deep beams avoided (see Fig. 3), and fore and aft girders made shallow with closely spaced stanchions rather than deeper girders with more openly spaced stanchions, and the girders should be kept as narrow as possible so that they may be adequately insulated and have a meat rail placed on either side at as nearly 12-inch centers as possible (see Fig. 4). The stanchions must be insulated and sheathed, and, if made circular or rectangular, the insulation can readily be applied.

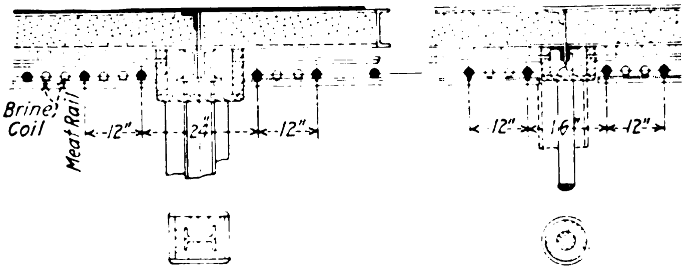

Fig. 4.—Sketch Showing Advantage of Narrow Girder Construction with Closely Spaced Stanchions Permitting Close Meat Rail Spacing

The hatchways are usually trunked with insulated trunks having large insulated doors on each side, opening into the hatch well, and the coaming should be kept as shallow as possible for maximum door height to facilitate cargo handling.

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If it is desired to carry chilled cargo in the hatchways, the hatch steel work must be so constructed as to carry the cooling coils, meat rails and insulated hatches, and the whole made readily portable, special attention being paid to the construction of the insulated hatches with adequate means for making them airtight.

Thermometers are carried into the compartment through 2½-inch or 3-inch tubes from the weather decks, the thermometers passing down through the tube and being suspended from a cord or chain. The upper end of the tube is carried from the deck by suitable deck plates raised above the deck level, made watertight and fitted with watertight screwed plugs, suitably named for attachment to the thermometer cord. A well-designed marine electrical resistance-type thermometer reading from a thermometer room in the vessel and leading to each compartment would be a very desirable addition to the hanging thermometers and would serve as a ready means of obtaining the temperatures at any time, especially during bad weather, when access to the deck is dangerous on account of the seaway.

General Carrier

In the refrigeration of a general carrier certain spaces should be provided for frozen cargoes, and, as these can be stored to considerable depths in bulk, the holds would be most suitable for the purpose. Above these should be provided spaces for chilled beef with the intermediate deck insulated above and below to prevent any possibility of cold striking through from the cold compartment to the warmer compartment. If the deck is not so insulated and a higher temperature cargo has to be carried above a frozen compartment, it is essential that at least 4 inches of sawdust insulation should be laid on the upper side of the deck, contained by suitable battens and temporary flooring over which would be placed the usual dunnage battens or gratings to carry the higher temperature cargo. Similar protection will be necessary, if a chill cargo is carried below a frozen one, to prevent ceiling drip.

In addition, spaces should be provided for the carriage of fruit, the refrigeration of which should be by the indirect air circulation system with special provison made for purifying the air in the chamber by means of introducing fresh external air which must pass over the cooling surface and be dried in so doing, with provision for the expulsion of vitiated air from the compartment, either from the floor or from the ceiling. Further, if apple cargoes are to be carried, provision should be made for ascertaining the carbon dioxide contained in the air. Recent experiments conducted between the Australian colonies and England have indicated that apples can best be carried when refrigerated by air circulation system and when the air is so purified that the carbon dioxide content is approximately 10 percent. An independent air circulation and cooling battery for each compartment would be very desirable when carrying mixed cargoes such as cheese, shell eggs, lemons, onions, etc., to prevent one commodity being tainted by the odor from another.

Operation

As the successful performance of a refrigerated ship depends as much upon the satisfactory operation of its refrigeration equipment and proper loading as on its satisfactory design and installation, it is of the utmost importance that suitable operating personnel be provided for the plant. The author suggests that the chief engineer of the vessel should be thoroughly familiar with the construction and operation of the refrigerating machinery equipment and the deck officers familiar with the requirements for proper loading, dunnaging, and temperature requirements of the perishable cargo being carried. The chief engineer cannot devote sufficient time to the refrigerating machinery to insure its satisfactory and efficient operation continuously, so that he should have the support of a chief refrigerating engineer, who would be in direct charge of the refrigerating machinery but under the jurisdiction of the chief engineer. This man should be the highest ranking engineer on the vessel next to his chief, have the same licenses, and be furnished with suitable accommodations and capable assistance to properly operate and overhaul his equipment.

Experience has shown that best results are obtained by placing the loading and treatment of the cargo in the hands of the deck department, which gives the chief engineer in writing or otherwise its requirements as to temperature, ventilation, etc.

Summary

Banana carriers require much more refrigerating power than meat or other refrigerated carriers, chiefly because the cargo has not been pre-cooled prior to loading. A banana carrier would be suitable for carrying citrus fruit or apples. Bananas are carried at temperatures from 53 to 55 degrees, oranges at approximately 42 to 45 degrees, lemons about 55 degrees, apples at 32 to 33 degrees, but particular attention is to be paid to their ventilation.

Frozen meat is loaded in bulk, packs about 95 cubic feet per ton, and is carried at temperatures from 12 to 15 degrees.

Chilled meat is carried in suspension from the under side of the decks at temperatures from 28½ to 29½ degrees with very even temperature regulation required, special arrangements being required for the brine circulation. The economical deck heights for chilled meat are 6 feet 6 inches from the deck to the under side of the meat rail, increasing by increments of 3 feet—that is, 9 feet 6 inches to 12 feet 6 inches to 15 feet 6 inches—any intermediate height being uneconomical stowage. Great care should be exercised in the design of the steel work to avoid breaks in the insulation surface and to provide suitable means for suspending the meat rails from the steel work.

All refrigerated compartments should be adequately scuppered with large-size non-freezing scuppers, preferably fitted with shut-off valves at their upper extremities.

Special attention must be given to making the insulated hatch plugs airtight.

The hull form should be as straight as possible; the cruiser stern shape would give better cargo form.

Decks, particularly for chilled meat carriers, should be flat, not cambered.

For general refrigerating carriers all hatchways should be trunked; double small hatchways would be better than single large ones, provided general cargo requirements can be cared for on non-refrigerated voyages.

All compartments should be fitted with adequate ventilation for drying them out after completion of a refrigerated voyage.

Cleanliness being essential, all insulation, protecting pipe battens and pipe coils must be arranged so that they can be cleaned, painted and varnished.

Refrigerating machinery equipment should be in few large substantial units rather than many small units, the larger units being more economical and reliable and taking less space. It is essential that all machinery equipment be so installed as to be readily maintained, overhauled and replaced in service and that standard makes of machinery be adopted to facilitate obtaining spare parts.

Refrigerating Machinery Equipment

The rules of a classifying society do not settle the size of refrigerating machinery for any particular refrigerated space, nor do they specify in terms of piston displacement or otherwise the size that a refrigerating machine should be to develop a ton of refrigeration.

Lloyd's rules distinguish between refrigerated vessels with less than 70,000 cubic feet of insulated space and vessels of larger capacity. For vessels of less than 70,000 cubic feet capacity, the machines can be of simplex construction, but for vessels of over 70,000 cubic feet the machines must be either of duplex construction or in duplicate, that is, must have two or more simplex machines.

Refrigerated vessels under the terms of this paper would in all probability be over 70,000 cubic feet, as it is not the intention of this paper to deal with general cargo or passenger vessels, only a portion of which are insulated and refrigerated for the cargo of refrigerated products.

In the following machinery size suggestions, the machines are, therefore, to be construed as of duplex construction in a single unit, or simplex construction in multiple units.

Lloyd's requirements provide that the refrigerating machinery shall be "of sufficient power to maintain the necessary low temperature in the cargo chambers in a tropical climate when running 18 hours per day. For cargo capacities of above 70,000 cubic feet, the machinery is to be either duplex or in duplicate. A sufficient amount of spare gear is to be supplied and stowed away where it is readily accessible. No spare gear will, however, be required in cases where two complete sets of refrigerating machines are fitted, each being of sufficient power to maintain the necessary low temperature in the cargo chambers in tropical climates when running 18 hours per day, provided all the working parts of these machines are interchangeable."

Refrigerating machines are sold commercially on a standard refrigerating tonnage and are supposed to be so rated that they will actually perform the amount of cooling work for which they are rated.

The standard ton of refrigeration in America is the elimination of 200 British thermal units per minute, or 12,000 units per hour. A 100-ton refrigerating machine would, therefore, be one which would eliminate 20,000 British thermal units per minute. The amount of work which any refrigerating machine can perform, when operating at constant piston displacement, varies directly as the evaporator or low pressure and inversely as the condenser or head pressure. The evaporator pressure is a direct function of the brine temperature, which in turn is directly dependent upon the temperature required in the cold chambers. The condenser pressure depends directly upon the temperature of the sea water and therefore is a function of the trade in which the vessel will operate. In the case of a carbonic acid machine operating with a refrigerated cargo at or about freezing temperatures, the falling off in its actual performance as between trading in North Atlantic waters and tropical waters would be very approximately 40 percent; that is, a machine which actually developed 100 tons when sailing in North Atlantic waters would develop 60 tons when sailing in tropical waters. Under similar conditions the falling off for an ammonia machine would be approximately 20 percent, the 100-ton machine in Atlantic waters developing 80 tons in tropical waters. This comparison covers the change in performance for constant brine temperatures which means constant evaporator pressures, but the performance of the machine will vary very materially with changes in back pressure; the higher the back pressure, the greater tonnage produced.

To have a standard machine size for a ton of refrigeration, it would be necessary to stipulate the back pressure and head pressure or ratios of these pressures under which the machine is to operate, and if these did not conform to the vessel's trading conditions, the size so arrived at would be of little use to the naval architect.

The naval architect in specifying the size of a machine required should state the piston displacement rather than the tonnage if he is to protect himself against an unscrupulous bidder who would overrate his machine's performance.

The author has endeavored to show the size of refrigerating machinery which should be provided for a general refrigerated carrier in terms of tonnage and piston displacement on Fig. 5. These curves are for ammonia and carbonic acid machinery respectively.

The ammonia machinery is based on a total piston displacement of not less than 8,000 cubic inches per minute per ton of refrigeration, and the carbonic acid machine on a total piston displacement of not less than 1,200 cubic inches per minute per ton of refrigeration. This latter figure corresponds very approximately to that used by the important manufacturers of English and European marine refrigerating machinery for their products. The capacities are the total cubic feet of insulated cargo space inside the insulation, and the tonnages are in each case intended to provide the amount of reserve required by Lloyd's for duplex or simplex machinery.

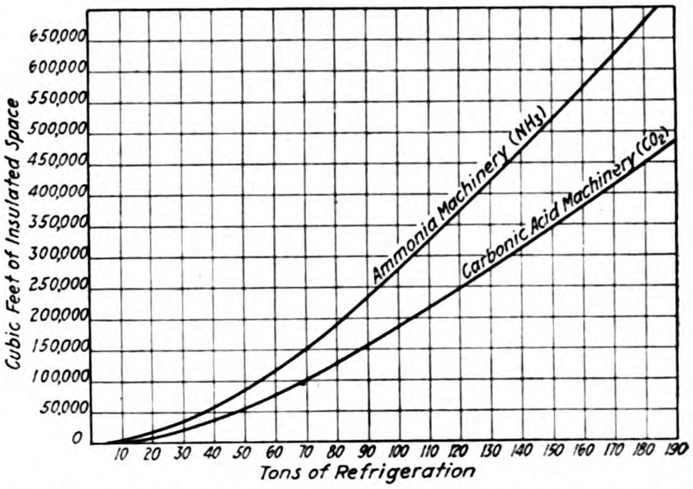

Fig. 5.—Curves of Machine Size for General Refrigerated Carriers Using Brine Suitable for Freezing Temperatures

Ammonia machines based on a piston displacement of 8,000 cubic inches per minute per ton of refrigeration. Carbonic acid machines based on a piston displacement of 1,200 cubic inches per minute per ton of refrigeration.

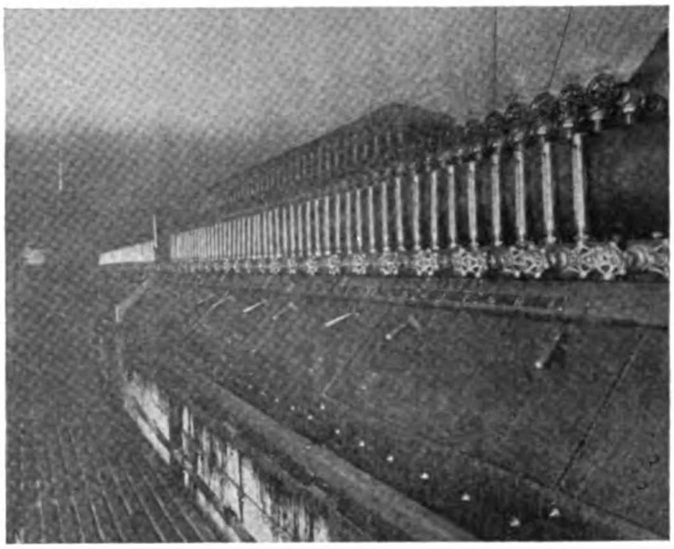

Fig. 6.—Brine Control Room

Example of Central Brine Control Room Adjacent to Refrigerating Machinery Space and from Which all Cooling Throughout the Vessel is Regulated. All Refrigerated Cargo Compartments are Closed and Inaccessible after the Cargo is Loaded.

As an example a vessel having 300,000 cubic feet of space inside the insulation would require carbonic acid machinery of 136 tons' capacity with a piston displacement of 163,200 cubic inches per minute or ammonia machinery of 105 tons' capacity with not less than 840,000 cubic inches of piston displacement per minute.

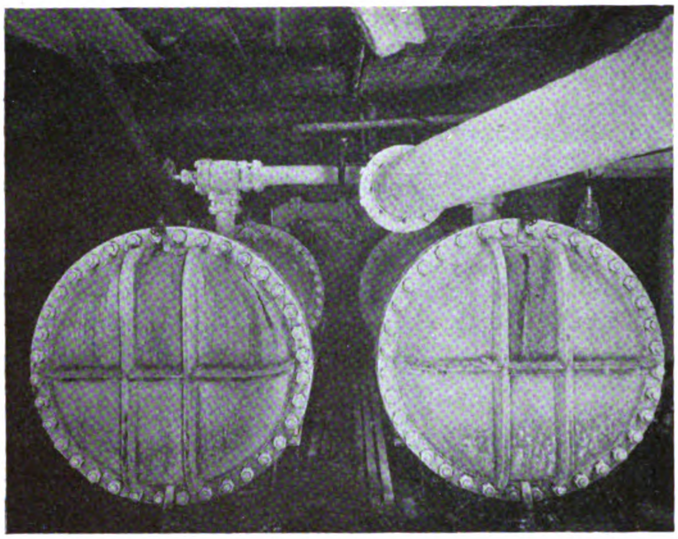

Fig. 7.—Efficient Brine Cooler Construction

The Coolers are Placed in an Insulated Compartment, Themselves not Insulated, and are at all Times Readily Examined or Repaired.

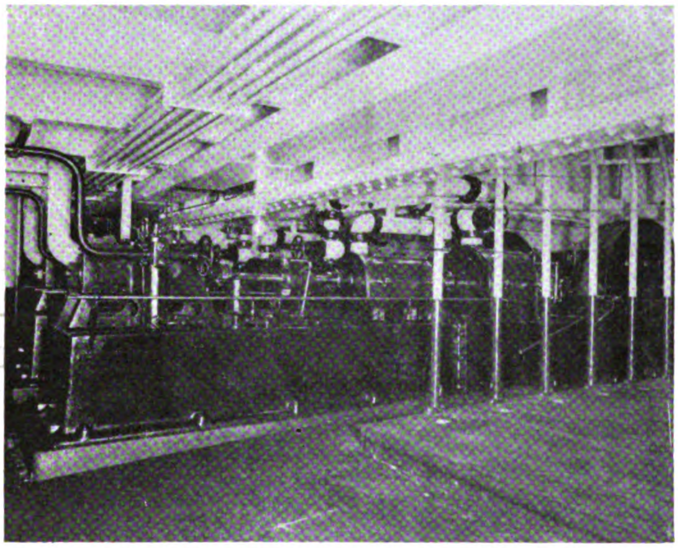

Fig. 8.—Two Large Steam-Driven Refrigerating Machines Installed in a 'Tween-Deck Space

These Machines are Each of 80 Tons Refrigeration Capacity and are Suitable for a Frozen Meat Carrier or General Cargo Carrier of about 375,000 Cubic Feet Insulated Cargo Capacity, or about 150,000 Cubic Feet of Banana Capacity.

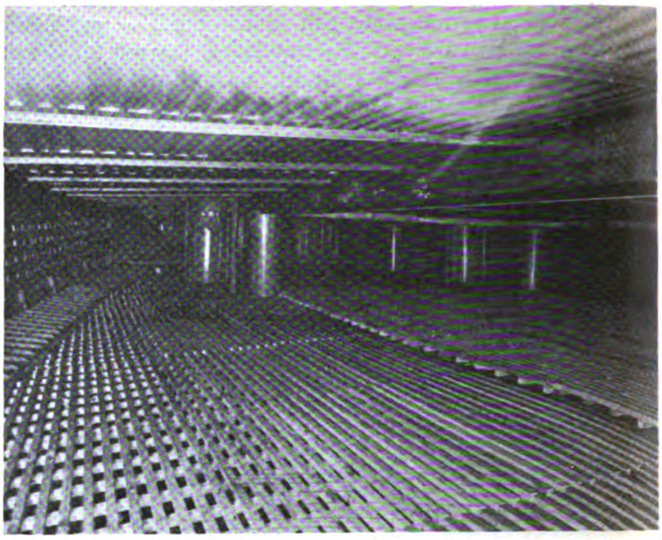

Fig. 9.—'Tween-Deck Cargo Space

Example of Complete 'Tween-Deck Cargo Space Ready to Receive Cargo, and Fitted with Portable Gratings on Deck Instead of Dunnage Battens. Dunnage Battens are Preferable where Non-refrigerated General Cargo has to be Carried in Refrigerated Spaces, as Their Use Reduces Grating Damage and Facilitates Removal and Stowage When Not in Use.

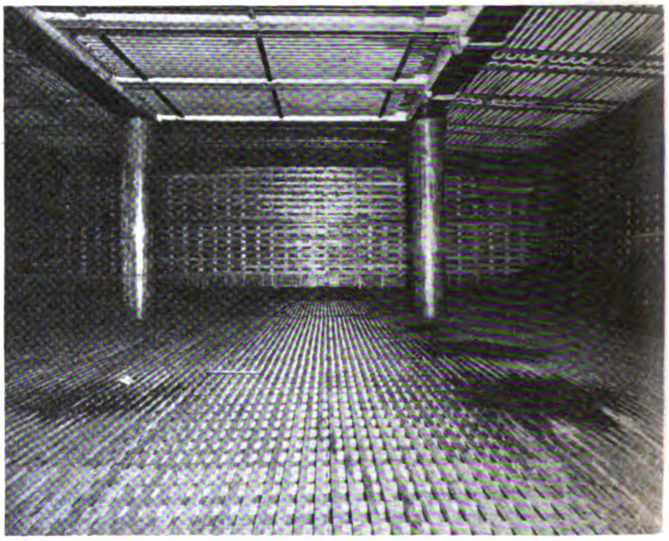

Fig. 10.—Completed Deep Hold

Note the Coil Protecting Battens and Fixed Dunnage Battens below the Coils, also Portable Cooling Coils in Hatchway.

It is important that the piston displacement should be at the normal operating revolutions of the machine, and not at emergency revolutions at which the machine might operate under breakdown conditions.

If such a refrigerating machinery equipment has to care for the requirements of the ship's provision rooms and passenger accommodation cooling in addition to its cargo work, the tonnage should be increased to take care of the extra load, as the above figures are intended to cover cargo requirements only. If the vessel is to handle large quantities of cargo, which have not been precooled before loading, the machine sizes would have to be very materially increased from those shown on the curves, which are intended for ordinary refrigerated trades, where the cargo has been refrigerated before being loaded into the vessel. The curves, therefore, would not apply to banana vessels.

The horsepower required to operate a carbonic acid machine is always greater than the power required to operate an ammonia machine under the same conditions despite the smaller piston displacement of the carbonic acid machine. This is due to the physical properties of the substances and cannot be changed, but the difference in power is, in the opinion of the author, not important on board ship.

A simplex refrigerating machine may be defined as a machine having one or more compressor units which can only be operated collectively. Such a machine of large capacity usually takes the form of a horizontal straight line tandem unit, driven by a compound steam engine, the high-pressure steam cylinder, low-pressure steam cylinder and refrigerating compressor being arranged tandem in a straight line on a common bedplate. Smaller size simplex machines are constructed with single-acting, single or double vertical compressors arranged on a common bedplate side by side with their operating motor or engine.

A duplex machine consists of two compressor units driven by a cross-compound steam engine, one compressor being in line with, and tandem to each steam cylinder, the pair being arranged on parallel bedplates, and operating as a compound steam unit but so arranged that if one side breaks down the other side can be operated separately, either as a single steam

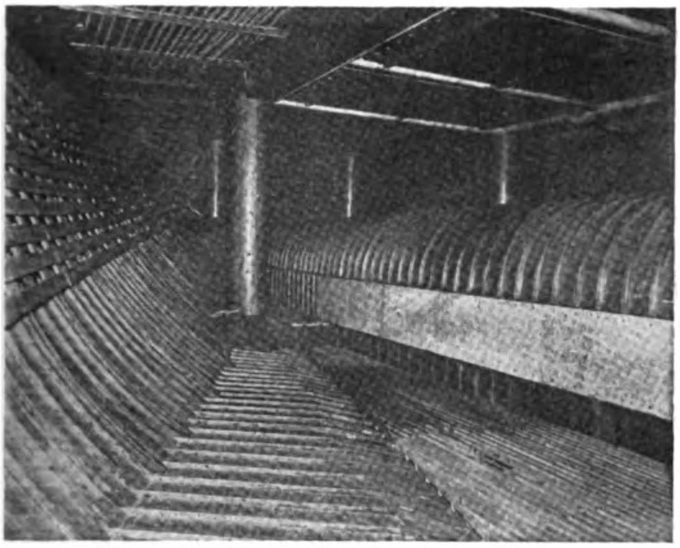

Fig. 11.—Completed Aft Hold in Single Screw Ship

Note Coil and Fixed Dunnage Battens, also Metal Protection over Cooling Coils under the Hatchway, on the Shaft Tunnel Sides.

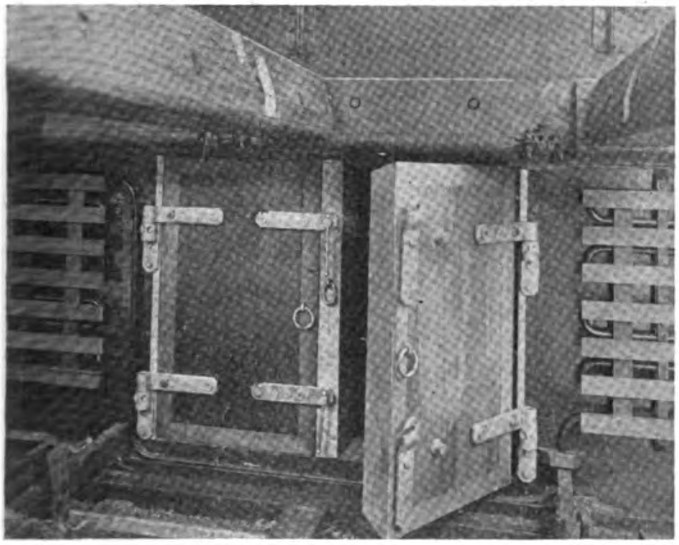

Fig. 12.—Trunked Hatchway 'Tween-Deck Construction

Note the Massive Door and Fastening Construction Necessary where Cargo is Loaded in the Hatchwell. In This Case the Hatchwell is Refrigerated as Well as the Compartment it Serves. In the Picture the Hatch Coaming and Strong-Back Metal Protecting Plates Have Not Yet Been Fitted.

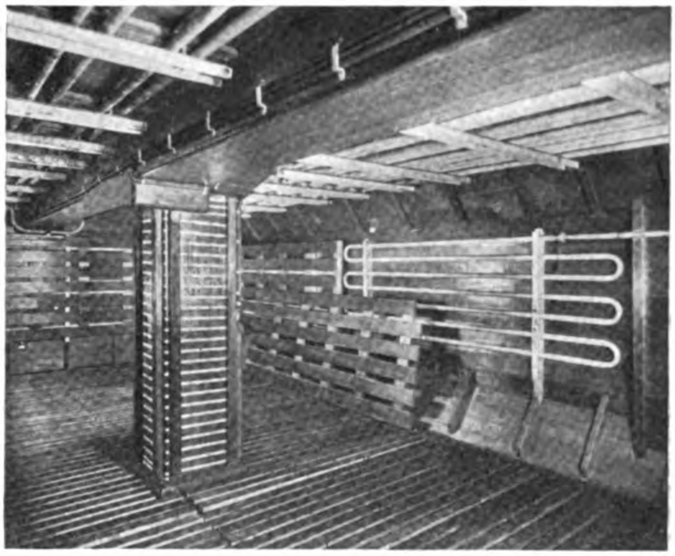

Fig. 13.—Compartment Showing Advantage of Portable Coil Protecting Battens for Cleaning and Painting

Note the Disadvantage of the Deep Fore and Aft Overhead Girder and Wide Pillar Spacing, Causing Loss of Meat-Hanging Space and Unsatisfactory Loose Stowage.

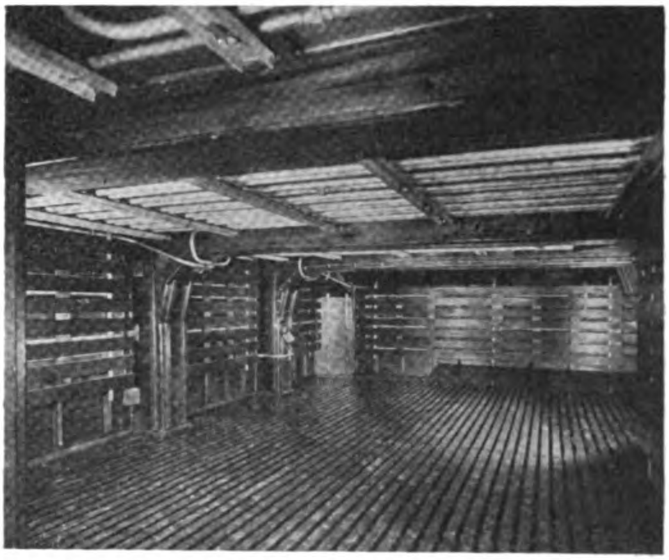

Fig. 14.—'Tween-Deck Compartment

Example Illustrating Disadvantage of Deep Web Frames and Beams, Resulting in Bad Stowage Space and Loss of Meat-Rail Capacity.

cylinder machine or as a compound unit with the damaged compressor disconnected.

The space occupied by a duplex unit and its weight is less than that of two simplex units of collectively equal capacity, but the safety against breakdown and flexibility in operation are vastly in favor of the simplex units, which, in the opinion of the author, is the only type to be considered on large refrigerated vessels.

In vessels carrying mixed refrigerated cargoes, the lowest brine temperature will be governed by the lowest cargo temperature required, and for a frozen cargo this should be about 0 degrees F. For the carriage of chilled cargoes the brine could be about 15 to 18 degrees F., and for purposes of passenger or crew's provision rooms, the brine would require to be similar to a frozen condition.

A general refrigerated carrier could, therefore, be arranged so that its machinery could function with two brine temperatures, some of the machinery operating at zero brine, and some at 15 degrees F. brine, but inasmuch as this would require subdivision of the refrigerating units, the author recommends that in all cases one brine temperature only be produced by the refrigerating machines, and that where some higher brine temperatures are desired (such as for the carriage of chilled beef or fruit) these be produced in mixing tanks, and the refrigerating machinery be operated with one temperature brine only. Such a system has already been referred to in discussing chilled meat carriage.

As a choice between the use of ammonia and carbonic acid machines respectively on shipboard, it is very difficult to make any definite suggestion, but the following comparison may be helpful.

The size and weight of the two types are approximately the same, as is also the space required.

The cost is usually about 10 percent greater for carbonic acid than for ammonia.

The operating power is in favor of ammonia by as much as from 10 to 30 percent, depending on the conditions, but the author holds this unimportant, as the difference in refrigerating power would be a very small percentage of the ship's operating power.

A Steel Weight Nomogram*

By E. V. Telfer, M. Sc., Ph.D.

While the nomogram here described has been worked out for British standards and practice, the principle involved is applicable to any others and is of interest to all who are concerned with steel structural work. We hope, with Dr. Telfer's assistance, to publish later a nomogram applicable to American standard sections and in a form for immediate practical use.—The Editors.

THE importance of the accurate and rapid calculation of the weight of the many and various structural items constituting a ship can scarcely be overestimated. At some period or other the detailed weight of a vessel must be calculated and whenever this is done it must be carried out in the least possible time. Other things being equal this necessitates that each individual and constituent calculation be performed by methods which mechanize mental effort. The weight of steel plates is rapidly obtained on special slide rules but the calculation of the weight of steel sections met with in shipbuilding has not, to the best of the present writer's knowledge, been reduced to the manipulation of a self-contained special slide rule. In fact it appears very doubtful whether a slide rule at once simple and comprehensive can possibly be constructed for shipbuilding sections. Such sections as channels and bulb angles, for example, do not have zero area for zero web thickness; and with increasing web depth the area of the flanges adopted also changes in a manner quite impossible to calculate on an ordinary slide rule. However, while slide rule treatment is out of the question, nomographic treatment appears to be exceptionally convenient. This latter enables a nomogram to be developed which is capable of giving the weight of any standard channel, bulb angle, angle bar, tee bar, I girder or bulb plate of any thickness and any length in certainly less than ten seconds once its manipulation has been mastered by the operator. This nomogram not only enables the foregoing weights to be obtained but also accommodates the calculation of the weight of steel plates and solid and hollow rounds. Thus all the really important structural weight calculations to be made in the design of a ship are reduced to the operation of one nomogram.

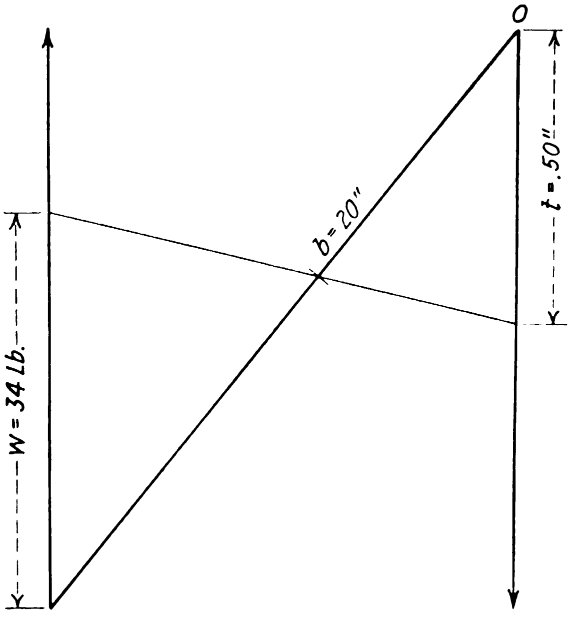

Fig. 1

Construction of the Nomogram

Consideration of the problem will show that the nomogram must consist of two distinct parts: one giving for every thickness and type of section the weight per foot run; and the other to convert this weight for any total length of plate or bar, into the total weight of the plate or bar. The construction of the nomogram can be best explained by describing how it effects the calculation of the weight of steel plates.

The relation between the weight of a plate in hundredweights and its principal dimensions is expressed by the following formula:

$$W = \frac{l.\,b.\,t.}{33} \qquad \ldots\ldots (1)$$

l being the length in feet and b and t being in inches the breadth and thickness respectively. If w be the weight in pounds per foot run, then

$$w = 3.4\ b.t \qquad \ldots\ldots (2)$$

$$\therefore W = \frac{l.\,w}{112} = \frac{l.\,b.\,t.}{33} \qquad \ldots\ldots (3)$$

Expressions 2 and 3 must be successively evaluated to obtain the complete weight of any plate.

Expressions such as these can be expeditiously solved by the type of nomogram known as the Z chart. If in Fig. 1 we draw two parallel scales of w and t each evenly divided but in opposite directions, the scales being so chosen as to embrace the working ranges of w and t respectively, then by drawing the diagonal joining the respective zeros of these scales it can easily be shown that this diagonal may be used as the breadth scale for our particular problem. By joining any weight to any thickness the intersection with the diagonal will give the breadth which together with the thickness gives the required weight. Thus suppose we joined t = .50 inch to w = 34 pounds then it follows that b must equal 20 inches. To show that this point on the diagonal is correct it is obvious that if we halve the thickness, i. e., take t = .25 inch, and join through the b = 20 inches spot, our line intersects the weight scale at half the previous weight, i. e., w now equals 17. Thus in a similar manner by joining up other values of w and t the whole of the breadth scale can be progressively calibrated. This need not necessitate extraneous calculation work for, if we again consider expression 2, we see that, if we choose $t = \frac{1}{3.4}$, i. e., 0.294 inch, the expression reduces to w = b; and thus by joining rays from this t value of 0.294 inch to successive values of w the intersection of each ray with the diagonal gives the value of b numerically equal to the corresponding w. From this reasoning the construction and manipulation of the right half of the main nomogram shown in Fig. 2 will be easily followed. Actually however in this nomogram the weight per foot run of a plate is never required, it being only an intermediate step in the calculation of total weight. For this reason the weight per foot run scale shown in Fig. 2 does not refer to plates but is only calibrated because of its use in connection with bars and solid rounds in the fuller application of the nomogram. The weight per foot run shown on

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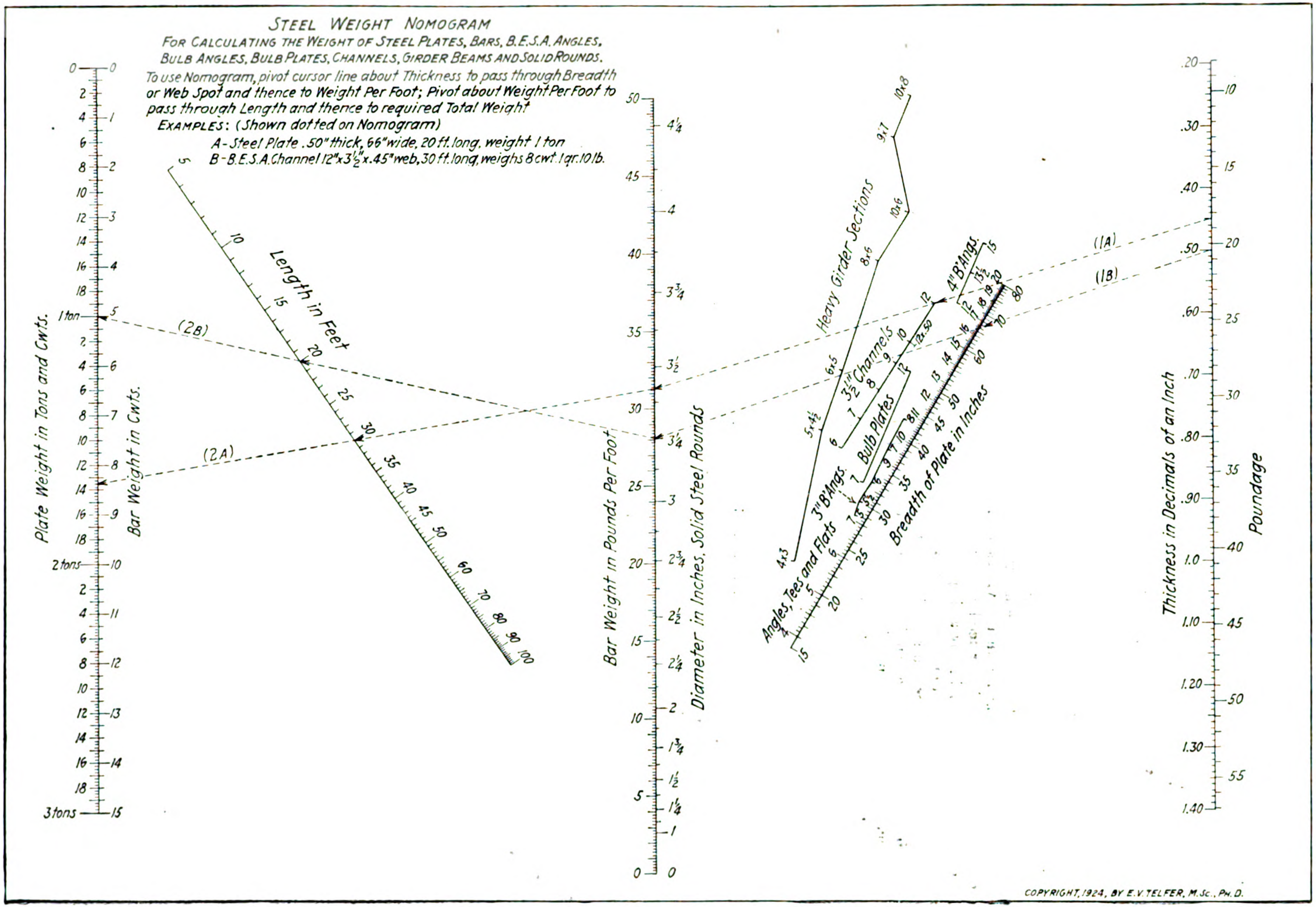

STEEL WEIGHT NOMOGRAM

FOR CALCULATING THE WEIGHT OF STEEL PLATES, BARS, B.E.S.A. ANGLES, BULB ANGLES, BULB PLATES, CHANNELS, GIRDER BEAMS AND SOLID ROUNDS.

To use Nomogram, pivot cursor line about Thickness to pass through Breadth or Web Spot and thence to Weight Per Foot; Pivot about Weight Per Foot to pass through Length and thence to required Total Weight

EXAMPLES: (Shown dotted on Nomogram)

A-Steel Plate .50" thick, 66" wide, 20 ft. long, weight 1 ton

B-B.E.S.A. Channel 12"x$3\frac{1}{2}$"x.45" web, 30 ft. long, weighs 8 cwt. 1 qr. 10 lb.

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Plate Weight in Tons and Cwts.
Bar Weight in Cwts.
1 ton
2 tons
3 tons
Length in Feet
Bar Weight in Pounds Per Foot
Diameter in Inches, Solid Steel Rounds
Heavy Girder Sections
10x8
9x7
10x6
8x6
6x5
5x4½
4x3
4" B'Angs.
3½" Channels
Bulb Plates
3" B'Angs.
Angles, Tees and Flats
Breadth of Plate in Inches
Thickness in Decimals of an Inch
Poundage
(1A)
(1B)
(2A)
(2B)

Fig. 2.—Steel Weight Nomogram

the scale is only one quarter that of the true weight per foot of plates.

The left half of the nomogram is constructed in an analogous manner. A third parallel, evenly divided scale is drawn on the extreme left of the nomogram to embrace the working range of total weight. This scale is calibrated in the opposite direction to the weight per foot run scale and as before the diagonal joining the respective zeros of these two weight scales is drawn in. This diagonal forms the length of plate scale and is very simply calibrated. As the weight per foot scale only represents $w = \frac{w'}{4}$, we see that

$$W = \frac{4w.l}{112} = \frac{w.l}{28}$$

Thus, if we take w = 28 pounds, by joining progressive rays to each division on the total weight scale the corresponding intersections with the diagonal give the values of length numerically equal to the particular total weights. All the scales are then subdivided as minutely as is practically convenient, the total weight scale being in tons, cwts. and qrs., the length scale in feet, the breadth scale in inches and the thickness scale in hundredths of an inch one side of the line and pounds as in Admiralty practice on the other. The weight of any normal plate can now be expeditiously obtained. The particular routine will be summarized later.

Weight of Bars

The weight of bars will now be considered. The most elementary is the ordinary angle bar whose weight is usually calculated by the formula

$$w = 3.4\ (A + B - t)\ t \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

where A and B are the respective flanges in inches.

Comparing this formula with the accurately calculated weights given in the latest publication of the British Engineering Standards Association it is found that it produces very accurate results, this of course being due to the fact that the bosom and toe fillets neutralize each other. The most convenient way of nomographing the above expression is to treat it as a plate of breadth (A + B — t) and thickness t. The ordinary plate width scale is not however of convenient range for this purpose and thus a new scale on the opposite side of the plate width diagonal has been constructed each point on which corresponding to one quarter of the original. The weight per foot run scale gives the correct weight for bars owing to this scale modification. It should be noted that angle bars as rolled always have flanges of equal thickness. This is not the case with other sections as will be pointed out later.

To use the nomogram to find the weight of a bar of given length and scantlings, the thickness is joined through the value of the equivalent width to intersect the weight per foot scale. This intersection is then joined through the value of length on the length diagonal to intersect the weight scale at the required value of total weight. At this point it should be noted that the weight scale to be used for bars is the right hand side of scale which owing to the above mentioned modification in the weight per foot scale is only one quarter of that of the plate total weight scale. This duplication of scales has of course been adopted to have the largest possible scale for the respective total weights usually met with in practice. It is obvious of course that the angle bar scale can also be used for tee-bars and for thin rectangular packing or flats. By an artifice it can also be used for steel stem bars. If the smaller dimension of the bar be divided by four and read off on the thickness scale, the larger dimension read off on the bar scale, then the total weight will be read off on the *plate* total weight scale.

Channels

Coming now to the case of channels, in the B. E. S. A. report previously referred to there is given the following approximate formula for the area of channels:

$$S = At_1 + 2(B - t_1)\ t_2 + 0\,3\,\gamma_1^2 \;\ldots\ldots\ldots\ldots\ldots(5)$$

The symbols have the significance shown in Fig. 3. At first sight the number of variables in this expression would seem to make nomographic presentation somewhat complicated. Actually this complication is more apparent than real. Channels can be divided into groups having 3, 3½ and 4-inch flanges and each group having a range of web depth and thickness. Furthermore the B. E. S. A. channels have, for every size of web and flange, constant flange thickness and fillet radii. Each channel has a standard web thickness and only this thickness is altered over the whole rolling range of each particular section. Thus for any standard channel the above expression can be split up into two terms, one a constant and another which varies with the web thickness. The expression when so transformed becomes

$$S = (2\ Bt_2 + 0.3\,\gamma_1^2) + (A - t_2)\ t_1 \;\ldots\ldots\ldots\ldots(6)$$

This is of the form

$$S = X + Y t_1 \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

which can be very simply nomographed. Had X been zero then the nomogram would have taken precisely the same form as the plate nomogram, Y in this case being analogous to the plate width. However all that is necessary to take X into account is to modify the basis diagonal which instead of joining the respective zeros of the thickness and weight per foot run scales, the zero of the former is joined to the value of X on the latter. The Y point is then obtained by joining any t to the corresponding value of weight per foot and noting the intersection with the basis diagonal. The B. E. S. A. formula, it should be remembered however, is only an approximation and while it is certainly a good one, for our particular purpose it is unnecessary. In our nomogram we intend to cater only for British Standard channels.

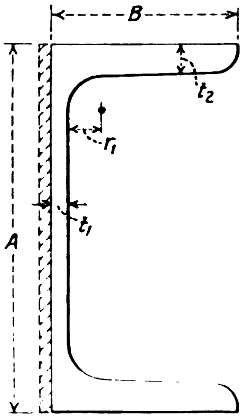

Fig. 3.—Extra Material Added Only to Web

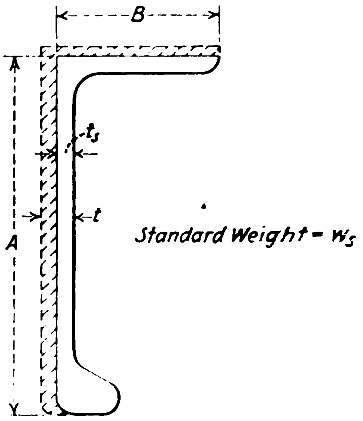

Fig. 4.—Extra Material Added to Both Web and Flange But Addition to Flange Only Half That to Web

The B. E. S. A. report contains the exact weight of each channel for its particular standard web thickness. Thus in the light of the foregoing formula we can extrapolate this weight for all thicknesses over the whole rolling range. To do this we must first calculate the weight when the web thickness is zero by subtracting the weight of the rectangular bar of height equal to the web A and thickness equal to the standard thickness. This can of course be done by using the angle bar scale. The standard thickness is joined through the web depth on the angle scale to intersect the weight per foot scale. This weight is subtracted from the standard thickness weight and thus the zero web weight is obtained. This weight is obtained for every B. E. S. A. standard channel and by using the method outlined above the web scales can be constructed in the nomogram. This has been done and it will be seen that the web scales for the 3, 3½ and 4 inch standard flanges are shown separately in the nomogram.* To obtain the weight of any length of a B. E. S. A. channel all that is necessary is to join the thickness through the particular web and flange spot to intersect the weight per foot run scale; this intersection in turn is joined through the length spot on the left half of the nomogram to intersect the total weight scale on its right hand graduations to give the required total weight.

I-Girders and Bulb Angles

The cases of the B. E. S. A. beams or I-girders and bulb plates are precisely analogous to that of the channel. For any particular section, variations in web thickness merely affect the web itself and are equivalent to the addition of a rectangular bar to the standard section. These beams and bulb plates can therefore be nomographed in the same manner as channels. This has been done in the nomogram given in Fig. 2.

The case of the bulb angle is slightly different for when the web thickness is altered the flange thickness is also modified. According to the B. E. S. A. report the modification in flange thickness may be taken as half that of the web. Reference to Fig. 4 will show that the variation in weight with web thickness is expressed by the following formula:

$$w = w_s - 3.4\left(A + \frac{B}{2} - \frac{t_s}{2}\right)t_s + 3.4\left(A + \frac{B}{2} - t_s + \frac{t}{2}\right)t \quad (8)$$

This expression shows that the weight does not increase linearly with thickness but parabolically. For our purpose a linear variation is essential. We must therefore determine the equation of the slope of the foregoing parabolic expression at the point of standard thickness in order to obtain the best linear expression over the practical working range. Thus differentiating the above we have

$$\left.\frac{dw}{dt}\right|_{t = t_s} = 3.4\left(A + \frac{B}{2}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

Thus the corresponding linear expression becomes

$$w = w_0 + 3.4\left(A + \frac{B}{2}\right)t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (10)$$

where w_0 is the apparent weight for zero web thickness. Its value can be calculated in the same way as for channels and hence for each standard bulb angle the web scales constructed. Alternatively instead of determining the zero web weight the change in weight for 0.20 inch change in thickness can be calculated; and this weight added to the standard weight enables a more convenient value to be used for determining the web spots on the nomogram. Both methods were used in the construction of the nomogram and separate web scales are shown for bulb angles with 3, 3½ and 4-inch flanges.†

Solid Rounds

The only remaining feature of the nomogram is the means to be adopted for calculating the weight of solid rounds. Solid rounds in ship work are now usually of steel and since for every diameter there corresponds a definite weight per foot, the right hand side of the weight per foot scale can be calibrated to read off directly the diameter of the solid round corresponding to each particular weight. This has been done in the nomogram and it should be noted that the total weight scale to be used in conjunction with the solid rounds is the smaller one as used for the other types of bars. However as the diameter range only extends to 4¼ inches, this can be virtually doubled if in any particular case the actual diameter be halved in referring to the rounds scale and then the total weight read off on the *plate* total weight scale. Similarly the weight of hollow rounds can be obtained by finding the total weights corresponding to the outer and inner diameter and subtracting the latter from the former.

Manipulation of the Nomogram

The manipulation of the nomogram will now be discussed. In joining from one scale to another it is of course not desirable to pencil on the nomogram. A more convenient and more rapid method is to use a strip of thin transparent celluloid about 2½ inches wide and of length amply sufficient to embrace the total width of the nomogram. Along the center of this strip a "hair" line should be drawn. From its analogy to the similar device on a slide rule this strip may be conveniently known as a cursor. Thus suppose the weight of a plate is required. The cursor line is placed over the thickness spot and kept in position by a hard pointed pencil directly above the spot. The cursor is then swung round until the hair line passes over the breadth spot. The cursor is maintained in this position and the pencil brought to the point at which the hair line crosses the weight per foot line. The cursor is in turn swung about this point until the hair line passes over the length spot and then the desired weight can be immediately obtained under the hair line on the total weight scale. This process is precisely analogous for all other sections since in their case the web spot takes the place of the breadth spot.

Numerical Examples

Two numerical examples are shown dotted on the nomogram. One shows that a plate 0.50 inch thick, 66 inches wide and 20 feet long, weighs one ton, while the other shows that a B. E. S. A. channel 12 inches by 3½ inches by 0.45 inch web, 30 feet long, weighs 8 hundredweights 1 quarter 14 pounds. The arrows on the respective rays should make the requisite manipulation quite clear.

In the latest B. E. S. A. Report it is recommended that all sections be ordered by size of flange, size of web and weight per foot thus eliminating the specification of web thickness. The practical justification of this recommendation is of course obvious yet the use of web thickness must be retained for some purposes. When a particular section has only its weight per foot specified it is thus a simple matter to refer to the nomogram and find the web thickness that corresponds to it.

Again for some strength purposes such as in the design of deep girders with rolled sections acting as flanges it is occasionally required to find channels and bulb angles of equal area. Thus, if a certain girder is specified to have channel flanges but these cannot be obtained in time and bulb angles are available, the nomogram will give the whole range of size and thickness of bulb angles which have identical weight per foot with the specified channel. All that is necessary in this case is to place the cursor hair line over the constant weight per foot, the point of a pencil placed over the weight spot keeps the cursor in position and as this is swung round simultaneous values of thickness, size and type of bulb angle can be read off under the hair line.

As previously mentioned only the B. E. S. A. sections are shown on the nomogram. As time goes on these sections will be more and more used and "odd" sections will tend to be eliminated. It should be the aim of the naval architect to see that the sections used in a particular design are as few as possible and all B. E. S. A. sections. In this way the purpose of the B. E. S. A. will be fulfilled. In the meantime, however, "odd" sections will continue to occur and for these the nomogram will serve as a useful means of approximating to their weight by sight interpolation between the standard sizes.

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*For the sake of clearness and owing to the small scale of Fig. 2, the web scales for 3-inch and 4-inch flanges have been omitted.

† Only the 3-inch and 4-inch flange scales can be conveniently reproduced in Fig. 2.

Admiral Taylor to Head Naval Architects' Society

Elected President for Three-Year Term—Proceedings of Thirty-Second Annual Meeting of the Society of Unusual Interest

AT the thirty-second annual meeting of the Society of Naval Architects and Marine Engineers, held at the Engineering Societies Building, 29 West 39th Street, New York City, on November 13 and 14, Rear Admiral David W. Taylor, U. S. N., formerly Chief Constructor of the United States Navy, and one of the honorary vice-presidents of the Society, was elected president of the Society for a three-year term. Admiral Taylor is one of the most widely known authorities on naval architecture in this country and abroad and has taken a leading part in the affairs of the Society since its inception, contributing many of the most valuable papers in its transactions.

Admiral D. W. Taylor, President-Elect

The other officers elected for the term expiring December 31, 1927, are as follows:

Honorary Vice-President: Andrew Fletcher.

Vice-Presidents: Lewis Nixon, Rear Admiral Hutchinson I. Cone, U. S. N., Retired; Charles F. Bailey, Joseph W. Powell.

Council Members (representing members of the Society): Richard H. M. Robinson, William G. Coxe, J. H. Mull, Robert Haig, Rear Admiral Charles W. Dyson, U. S. N.; Rear Admiral John D. Beuret, C. C., U. S. N.

Council Members (representing associates): Charles M. Wales, Ira A. Campbell, Philip A. S. Franklin.

Council Member (representing members for term expiring December 31, 1926): Rear Admiral Harold P. Norton, U. S. N.

Executive Committee: Stevenson Taylor, Washington L. Capps, Walter M. McFarland, Frank L. DuBosque, Joseph W. Powell, Homer L. Ferguson, Alfred Gilbert Smith. (President and secretary-treasurer ex-officio members.)

Committee on Papers: Frank L. DuBosque, J. Howland Gardner, Herbert L. Aldrich.

Secretary-Treasurer: Daniel H. Cox. Assistant Secretary-Treasurer: Thomas J. Kain.

Forty-three members were elected to the Society this year; 9 associate members and 6 junior members. Four were transferred from the class of associate members to full membership.

The annual report of the secretary-treasurer shows the finances of the Society to be in excellent condition, with total resources of $85,505.42 of which $65,138.83 comprises the endowment fund.

In opening the annual meeting on Thursday morning, November 13, Captain Walter M. McFarland, president of the Society, reviewed recent important developments in the marine field in part as follows:

Abstract of President's Annual Address

The period of the last 80 years has been one of wonderful progress. It covers the advance from paddle wheels driven by simple engines with pressures around 20 pounds and revolutions in some cases as low as 10 per minute to the modern turbine vessels where, even with gearing, the revolutions of the propeller are as high as 450 per minute. Steam pressures as high as 300 pounds have been used. Horsepowers have increased from a few hundred per vessel to 98,000 in the scout cruisers and 180,000 in the battle cruisers. Weights have been reduced from a figure of 2 horsepower per ton to 65 horsepower per ton and coal consumption has been reduced from 5 pounds per horsepower to 1 pound per horsepower.

During this period we have seen each particular phase of advancement develop to a high degree of perfection only to be followed by some great improvement which renders the previous stage obsolete for higher class vessels, so that the simple engine gave way to the compound, the compound to the triple and quadruple expansion engine and these in turn to the direct connected turbine, which itself has now been superseded by gearing of the mechanical or electrical type. We have also seen the advent of the internal combustion engine, first in the gasoline engine for small powers, where it still continues a favorite, and followed by the heavy-oil or Diesel engine for much larger powers.

The history of our country, with its wonderful opportunities, has made us all natural optimists and consequently it is anything but a pleasure to have to discuss conditions of discouragement. As I look back over the many meetings which I have attended, it seems to me that there has hardly been a time, except during the Great War, when the Presidential address did not have to refer to conditions in the merchant marine as discouraging. Just now we seem to be at the lowest point of the curve. In earlier days, although we were building no merchant vessels for foreign service, during a long period of years our shipyards were moderately busy with the construction of our naval vessels. This gave an opportunity for the display of the highest ability of our own members in their professional capacity and employment for a goodly number of artisans. The naval holiday of a few years ago shut down absolutely on any new contracts and in the meanwhile all of the old ones have been completed except for the two airplane carriers which were to have been battle cruisers. During the past session of Congress things looked hopeful for a time, when the House had passed a bill providing for a number of light cruisers, but, as has happened several times recently with other measures which would have been of great benefit to shipbuilding, this was held up in the Senate by the action of one or a few men who always protest loudly of their extreme solicitude for the workingman but, when the actual opportunity comes to do something for him, fail to respond.

Fortunately, there is always a certain amount of work for vessels in the domestic trade and during the year a number of creditable vessels have been completed and some put in service.

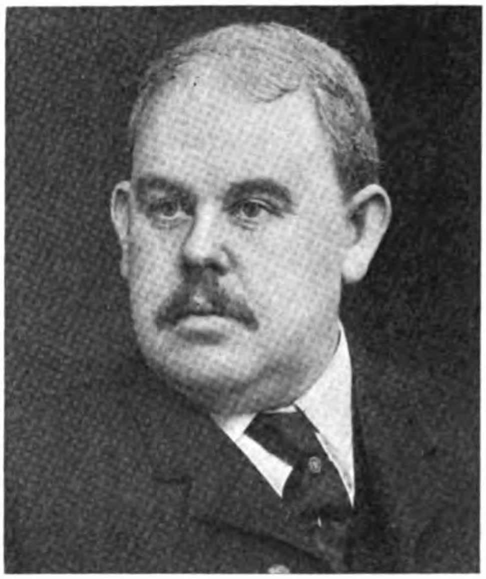
Some encouragement is held out to our yards and other builders of internal combustion motors in the program of the Shipping Board for converting certain of their vessels from steamers to motorships. Owing to the fact that the Government owns a very large number of vessels which are laid up and which, if allowed to remain in that condition, would ultimately have to be scrapped, it has been felt that something might be done by practically giving the hulls to shipowners who would agree to purchase and operate them, if equipped as motorships. The first cost in this way is relatively low so that the charges for interest, insurance and depreciation which count so heavily against a new motorship are reduced to a minimum. The figures which have been submitted in advocacy of this scheme, if correct, would indicate that these vessels can be operated so as to secure a profit.

This arrangement amounts to a subsidy in favor of motor building, and, as I understand, the object of its authors and advocates is to provide examples of motorships, whose performance is expected to show such an economy as to lead to the gradual displacement of steamers by motorships. In analyzing the subject of steamers versus motorships my study of the problem has not led me to expect the superseding of the steamer by the motorship. There are undoubtedly services on which motorships of a certain power and with the present price of oil are attractive, but it seems to me that the problem is not so much a technical one as a broad financial one. The very high thermal economy of the internal combustion engine with a consequent great reduction in fuel bill has a tendency to arouse enthusiasm which a careful study of all conditions does not entirely warrant.

The vital point, it seems to me, is the question of the cost of fuel. All the authorities who discuss the subject of the available known sources of supply of oil warn us that it is very far from inexhaustible. Some indeed are so pessimistic as to talk of the exhaustion of oil within a comparatively short period, say, two decades. The supplying of gasoline for motor transportation and other purposes is constantly increasing and this is the part of the oil business which gives the greatest returns. Those who are familiar with the subject know that every effort is constantly being made to increase the percentage of gasoline obtainable from oil, with the natural result that the part available for other purposes, including heavy oil for fuel, is constantly being reduced. Up to the present time the demand for oil of this kind is relatively small, so that the price has not as yet gone very high. The law of supply and demand, however, certainly makes it plain that, if steam motors were superseded by internal combustion motors, the great demand for oil would make its price so high that the thermal economy of these motors would be much more than offset by the cost of the fuel. From a different angle this same point of the supply of oil was discussed some years ago by Sir Charles Parsons, who pointed out that, if all steam vessels were to shift from coal to oil, there would not be enough fuel oil available in the world for this purpose alone. Indeed, many careful designers, even now, have this point in mind and insist that boilers shall be so designed that when the price of oil becomes too high they can readily shift to coal.

The work of our society is primarily scientific and technical but that should not prevent our being good business men at the same time, and indeed we shall be better technical men if we bear in mind that however perfect our designs from a purely engineering and scientific side, they are not a complete success unless their use results in a profit to the operators.

In closing Captain McFarland paid a tribute to Admiral Taylor, the newly elected president of the society, stating no one could have been selected who will more adequately fill the office or bring more honor to it. "He has been a devoted member of the society from its very beginning," Captain McFarland said, "and it is no reflection on others who have contributed valuable papers to say that those contributed by him constitute the most valuable collection which we have. Like so many other members of our society he is a graduate of our Naval Academy, where he made a brilliant record, and this was followed by a similar experience at the Royal Naval College of Great Britain, where he again made a record for high standing. He designed the Naval Experimental Tank and for a number of years conducted the tests. Our transactions have been enriched by his papers giving the results of these tests. During our Great War he filled with the highest credit the office of Chief Constructor of the Navy. His reputation is international. In many ways I look on the office president of the society as the greatest honor which can be conferred upon any member of our profession, but in selecting Admiral Taylor as the next president the society has not only honored him but honored itself."


Capt. W. M. McFarland, Retiring President

Aeronautics in Naval Architecture

By Commander J. C. Hunsaker, C. C., U. S. N.

ABSTRACT

As aeronautics passed from the hands of inventors into the hands of engineers it borrowed heavily from naval architecture as well as from other branches of engineering. But both aeronautics and naval architecture have in common the fundamental laws of fluid motion, balance and stability, and moreover have in common the practice of basing a design upon tests with reduced scale models. Consequently, as aeronautics acknowledges its largest debt for naval architectural knowledge and practices, it seems reasonable to inquire whether the time has not now come for some portion of this debt to be repaid to naval architecture in the form of aeronautical knowledge and practices which may usefully be applied in ship design.

Aeronautics during the period of the war received an enormous impetus. In England, Germany, France, Italy and the United States the best men in mathematical-physics, metallurgy, medicine, and in fact from every branch of science, even including botany and astronomy, applied themselves intensively to the solution of the problems of aeronautics. The results of this enormous program of research and experiment have given aeronautics such a firm foundation of fundamental knowledge, both theoretical and practical, that the practitioners of the older arts and sciences may well envy the aeronautical engineer.

As an example, consider that the naval architect today knows very little more about the stresses in a ship in a seaway than did Noah. Yet the aeronautical engineer is supplied with precise information as to the air pressure on any part of an aeroplane when performing even the most violent feats of aerial acrobacy. How much, if any, of this aeronautical knowledge is immediately applicable in naval architecture?

WARSHIP DESIGN

The great weapon of the aeroplane is the heavy bomb which explodes under water. To meet this, the warship requires the same kind and degree of underwater protection that is needed against mines. To avoid mines, warships keep clear of coastal waters. In the present state of the art, no airplane can carry a heavy bomb beyond such waters and release it at a safe height.

The aeroplane also can carry and launch standard torpedoes. Protection of the ship's side against torpedoes is the same whether the torpedoes be launched from an aeroplane or from a destroyer.

The ability to control long-range gun fire from aircraft makes it possible to fire at a target which is not visible from the ship. This places a premium on greater elevation of guns and may reduce the importance of the high fire control top on the mast.

One answer to the heavy bombing plane is the anti-aircraft gun. To carry a heavy enough bomb to be a menace, the plane is large and slow and cannot reach a great altitude. Similarly the torpedo plane in the present state of the art must come near to launch a torpedo and close to the water. We may see in a future battleship three batteries of guns: the main battery of 16-inch guns, a secondary battery of 6-inch guns to drive back destroyers, and a third battery of anti-aircraft guns to shoot down either bombing or torpedo planes.

Mines and submarines already have made coastal waters an unsafe region for a fleet. At sea, the only offensive aircraft to be met are those launched by the enemy fleet. Therefore, an essential feature of a modern fleet must be ability to throw out an air force when required.

The carrier is a new type of vessel which the naval architect and aeronautical engineer have worked out together. Underwater there is nothing new, but the high freeboard, absence of ordnance weights, high center of gravity and open hangar space introduce a great deal of difficulty.

On a battleship to carry aeroplanes, the arrangement of boat stowage, secondary and anti-aircraft guns and non-primary deck obstructions must be adjusted to provide room for the aeroplane's launching catapults and hoisting gear.

Aerodynamics

Hydrodynamics has become a somewhat sterile subject, and naval architects have in recent years, since D. W. Taylor's work, left it severely alone. However, the aeronautical sciences had the good fortune to enlist from the early years some of the best mathematical-physical brains in the world, and it is not surprising that the advances of aerodynamics have occasioned a renewal of interest in classical hydrodynamics.

The aerodynamic-hydrodynamic analogy is so close that the general conclusions from aerodynamic research apply directly to problems dealing with the flow of water. For this reason naval architects should obtain a great many useful or at least interesting ideas from aerodynamic experiments.

The Flettner rudder now fitted to a few merchant vessels is an example of the direct application in naval architecture of aeronautical knowledge. Applied to a ship, the Flettner type of rudder eliminates the steering engine.

Structural Materials

Aeronautics resembles naval architecture in sharing a practice almost unique in engineering work. This is the rigid control of weight and its balance. The naval architect saves a ton with satisfaction, but the aeronautical engineer normally tries to save pounds. A few tons overweight on a ship is not noticed, but 50 pounds overweight on an aeroplane may mean the sacrifice of a vital piece of military apparatus and make the machine a relative failure. The design of structural members is carried out with every refinement indicated by theoretical structural analysis and then checked by static tests on a full-sized aircraft. It is not satisfactory in aeronautical design to use a liberal factor of safety to cover uncertainties. Consequently methods and apparatus have been devised to measure strains in stressed members in order to determine their loads under static test and in service operation.

Naval architecture is frankly going entirely by experience with liberal factors of safety to cover uncertainty both in the longitudinal and in the transverse strength of vessels. Shipbuilding is necessarily conservative and, so long as the hull stresses in service are unknown, the weight to be saved by the adoption of better structural steels is somewhat indefinite. However, there are indications that naval architecture is about ready to take advantage in a practical way of the products of modern metallurgy. The marine engineers are already following the aeronautical and automotive engineers in the use of alloys. In England a few merchant vessels are being built to reduced scantlings with a steel of higher elastic limit than is usually employed.

If progress is to be made, our ship designers might well consider the manner in which the needs of aircraft designers have been met by intensive research to develop materials having the properties especially desired for aircraft construction. Eventually ordinary carbon steel was made to give double the strength of the "bicycle tube" standard by careful control of cold drawing and "blueing." It seems likely that the ordinary mild ship steel can be given very much improved physical qualities solely by control in rolling.

Ship Form and Steering

The steering of ships has developed from centuries of experience, and today a naval architect has fairly definite ideas on the subject. But experience is very slowly accumulated, and qualitative information is difficult to apply practically.

In aeronautics, from want of experience, intensive experimental and theoretical research has been conducted into the mechanics of stability and steering with the result that the stability of course of an airship or an aeroplane can be predicted from the plans. The equations of motion have been solved and a criterion of stability devised which will indicate whether a small deviation from the course will increase or will develop into an unstable oscillation. This is a case where the methods of aeronautics may be applied usefully in naval architecture.

As to the design of rudders themselves, the aeronautical literature already contains a great deal of information of immediate use to the naval architect. The center of pressure on flat and cambered surfaces, balanced or unbalanced, has been found for a great variety of shapes from tests made in air. There is ample evidence that the center of pressure is the same for air and for water. The aeronautical experiments indicate that the naval architect's conventional use of Joessel's formula for rudders is far from correct.

Propeller Design

Marine propeller design is based on data obtained from models and from trial trips. In either case similitude conditions are depended upon and the detail mechanism of propeller action is apparently considered too hopelessly complicated for successful analysis. The development of aeronautical propellers has in the main followed the blade element theory, and, although this theory is far from satisfactory, practical aeronautical propellers are designed which exceed 80 percent in efficiency and which meet torque and thrust conditions with reasonable precision.

One advantage of the detailed analysis comes from the light thrown upon the effect of the curvature of the back of the blade. It is now clear that the curvature of the back of the blade is most important. A high camber gives a high thrust per unit area and somewhat reduced efficiency.

other conditions being equal. Also, it is learned that for a cambered blade the angle of incidence may be from 2 to 8 degrees negative before the lift or thrust component of force on the blade element vanishes. This "angle of no lift" is a characteristic of the blade section. Consequently, the marine propeller designer's preoccupation with "pitch," variously defined, appears to be unnecessary, as pitch is not a true propeller characteristic. Likewise, "slip," whose definition involves pitch, becomes wholly deceptive. The abnormality of "negative apparent slip" is familiar to us, but we now know the words mean very little. What has happened in a case of negative slip is that the angle of incidence of the blades (measured from the face) is negative although the angle of incidence measured from the "angle of no lift" is still positive. Consequently the effective pitch is larger than the geometrical face pitch, and real and apparent slip are different.

At the present time the hydrodynamical circulation theory which has proved so useful in calculating the forces on wings and the distribution of pressure is being applied to propeller blades. The work is hardly complete, but it already appears probable that it will soon lead to a simpler and more precise procedure for the design of air propellers. Marine propellers are unique in having ever present the possibility of cavitation. I venture to suggest that an explanation of cavitation will be found in the distribution of pressure over the blade profile. This could be investigated theoretically by the circulation theory and experimentally with models using the methods applied to the study of aeronautics.

Resolution Unanimously Adopted by Society of Naval Architects and Marine Engineers

The record of our beloved president, Walter M. McFarland, whose term of duty expires on December 31, 1924, stands out clearly in the minds of all our members as an example of successful and devoted leadership, and sets a standard of accomplishment that his successor will find difficult to equal.

One of the earlier members of the society, practically all his life has been full of instances of his devotion to its cause.

For many years having been most active on the Council, deeply interested in all its problems and intimately acquainted with its members, he took up the reins of office with full knowledge of his duties and responsibilities and with a sincere desire to give his best to the organization.

By temperament, education and experience he was admirably adapted to hold this important office.

Under his direction the society has prospered. His untiring energy has been directed towards improving its usefulness and importance. His genial personality and unselfish devotion have endeared him to each and every member of the organization.

Therefore be it Resolved that:

The Society of Naval Architects and Marine Engineers place upon its records its deep appreciation of the faithful, devoted and successful service rendered by its retiring president Captain Walter M. McFarland, and that the secretary of the society be directed to present to him in writing a copy of this resolution.

Discussion

Dr. W. F. Durand spoke of the paper as most timely and demonstrating the interrelation of naval architecture and aeronautics. He had done considerable investigating at Leland Stanford University in recent years. The practical application of the theoretical blade analysis of propellers left something to be desired in the harmonizing of results. The work of Dr. Briggs, of the Bureau of Standards, on projectiles had a direct bearing on aeronautics and showed that the results of low speed experiments were likely to be misleading.

Admiral D. W. Taylor also remarked on the great value of the paper and the important work in aeronautic development accomplished by Capt. Hunsaker during the war. He was inclined to question the statement that certain methods of investigation, as the use of Pitot tubes, had originated with the aeronautic engineers, as naval architects had made use of them in former years. Speaking of the introduction of new structural materials, he drew attention to the fact that the great development of the manufacture of open hearth steel in this country was largely due to the demands of shipbuilding, commencing with the construction of the modern naval fleet in 1882.

Prof. Edward P. Warner* and Shatswell Ober*: In an endeavor to determine the aerodynamic properties of a yacht sail and a search for possible means of improvement in its performance, a series of researches have been undertaken within the past eighteen months, and have included both the testing of model sails in a wind tunnel and the making of actual measurements of pressure intensity at a large number of points over the surface of the sails of a yacht when under way. Our conclusions relative to the action of the sail, and in particular to the function of the jib, have in general agreed with Commander Hunsaker's, but there is one factor of tremendous importance which he fails to bring out.

An air plane wing acts at the same angle of attack to the relative wind throughout its span, but the sail of a yacht is twisted by the action of the air upon it, so that the angle between the wind and a straight line connecting the luff with the leach may vary as much as 30 degrees from boom to peak. The result is that it is impossible to keep the whole sail working at the most efficient attitude at one time, and one advantage of a relatively flat sail, particularly when the rig is a high one, is found in the reduction of this angle of twist. The part of the sail adjacent to the boom always works when on the wind at an angle of attack much larger than is efficient, far beyond the angle of maximum lift, to use the terms of the aeronautical engineer, and the primary service of the jib lies in establishing and maintaining a smooth streamline flow of air over the lee side of the sail, near the boom, where the flow would otherwise be inordinately turbulent and the driving force small. Since the twist of the sail is much larger in heavy winds than in light, the function of the jib is most important when the wind is strongest, and this explains why a cat rig has often proven satisfactory in light air, but not under other conditions.

We are in some doubt about the validity of the author's conclusions concerning aspect ratios in sails and the change of form with type of boat. Admittedly, the high aspect ratio of the Marconi rig is an advantage, but it seems probable that the peculiar merit of that rig is based rather on the existence of a vertical wind gradient and on the elevation of the peak into a zone where the wind velocity is considerably higher than it is close to the water. The fact that the Marconi rig has less twist than a gaff type is also an advantage.

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*Aerodynamical Laboratory, Massachusetts Institute of Technology.

It can, of course, be pulled flat when on the wind by exerting a direct tension through the sheet and leach of the sail, but it is almost impossible to keep a gaff from swinging far to leeward.

As for the section of the sail, it is not certain that the primary desideratum is different in boats of differing types. The object in every case is the same, to secure a maximum of driving force per unit of area with a minimum of heeling force. The factor of transverse, or leeway-producing, force is probably almost negligible in itself, its importance lying in the tendency to heel the boat. If the driving force per unit area were larger with a deep curvature than with a flat one, deep curvature would certainly be more popular on racing sails. It is our belief that the change of ideal form with changing type of hull, in so far as it exists, is due to the difference of "pointing ability" of the boat. The yacht with fine lines and with sails naturally more efficient than those of the work boat can head closer to the wind, and its sail therefore works at times at an angle of attack much smaller than that to which the sail of the working boat is ever likely to be set.

These are only a very few and scattered points. The really important thing is that, as Commander Hunsaker has pointed out, the laws of aerodynamics hold equally well for aircraft and for marine craft. Information gleaned for use on one can often be applied to the other, and the aeronautical engineer and his wind tunnel can be of real service in the design of ships, especially those with sail propulsion.

Hydraulic Seagoing Hopper Dredges

By Captain W. D. Styer, Corps of Engineers, U. S. A.

Abstract

THE mention of the word "dredge" probably conveys a variety of pictures to the average person who is more or less familiar with the more common types in general commercial use. However, as the subject of dredges in general is rather broad in scope, covering, as it does, so many vastly different types, I have selected as the subject for discussion in this paper a type of dredge which, while less familiar to the average person, nevertheless performs a mission of utmost importance to our foreign and domestic seagoing commerce. I refer to the hydraulic seagoing hopper type of dredge, an American invention, developed and operated by the Corps of Engineers of the United States Army for use in the maintenance and improvement of our seacoast harbors.

The important rôle which dredging plays in keeping our seaports open to the commerce of the world is generally not fully appreciated. Without constant maintenance of harbor and channels, important ports like New York, Philadelphia, Norfolk, Wilmington, N. C., Charleston, S. C., Savannah, Jacksonville, Tampa, Mobile, mouth of the Mississippi, and Galveston harbors would rapidly shoal to such an extent as to seriously interfere with navigation and in many cases entirely prevent the entrance of modern seagoing ships. New ports are developing and requiring the improvement of their outlets to the sea. A very large percentage of the work will have to be done by dredging and will in all probability be handled most economically in the future, as it has been in the past, by the hydraulic seagoing hopper type of dredge.

The development of the seagoing hopper dredge in this country was brought about by the need for dredging plant adapted to work on exposed ocean bars. Prior to the introduction of the seagoing hopper dredge, the cost of dredging on exposed ocean bars ran from 25 cents to $1 per cubic yard, according to the locality and amount of work. On account of the great cost, the deepening of these bars by the scour produced by jetties was regarded as the only practicable course.

The only kind of dredging plant that can operate economically on an exposed ocean bar is a self-contained dredge, which discharges the dredged material into hoppers in its hold and then steams out to sea to dump. In Europe the seagoing ladder hopper dredge has been extensively developed for this purpose.

As early as 1855 a commercial steamer was converted into a dredge by installing centrifugal dredging pumps, piping, etc., and construction bins in the hold. This was used for the improvement of the harbor at Charleston, S. C. It is believed that this was the first seagoing hopper dredge in this country.

In 1875 a side-wheel steamboat was purchased by the Government and converted into a dredge for use in the Savannah River and harbors on the Atlantic coast. She was a small steamer, originally built for carrying passengers and light freight, and carried only 100 tons on a 7½ foot draft.

The modern development of seagoing hopper dredges may, however, be said to date from the improvement of the Gedney Main Ship and Ambrose Channels in New York Harbor, notably the latter. Under contracts, a 30-foot channel from the Narrows to the sea was completed in 1891. The average unit cost for the work was 27 cents, far above that which is now expected for similar work.

In the late nineties, it was decided to improve the East Channel, now known as the Ambrose Channel, to a depth of 40 feet, and a contract was made for removing 42,500,000 cubic yards at a unit cost of 9 cents. The contractor was, however, quite unable to maintain the specified rate of progress, and withdrew in 1906 and the contract was thereafter annulled. As it was found impossible to obtain bids from private parties, the United States built additional plant and with this completed the work.

The period from 1900 to 1905 was one of rapid development of seagoing hopper dredges, largely on account of the experience gained at New York Harbor. The result of this is seen from the following table of unit costs:

	Cents
Bids for deepening Gedney Channel, 1884-5	35–59
Average unit cost of work on Gedney Channel up to 1891	27
Estimated unit cost for Ambrose Channel, 1899	10
Contractor's bid for Ambrose Channel (never successfully completed)	9
Average net cost all Ambrose Channel work, including work by government plant	6.4
Net cost of that part of the above done by government plant (the greater part)	5.65

The dredges built prior to 1900 were all comparatively small, with hopper capacity of 500 cubic yards or less, and were all of wooden construction. In 1902 the first of the larger dredges, the *Cumberland,* with a hopper capacity of 1,000 cubic yards, was constructed. About 1904, a fairly extensive program of construction of seagoing hopper dredges was undertaken. This program, the first to employ steel construction, included the *Delaware* of 3,000 cubic yards hopper capacity, the *Benyaurd, Manhattan* and *Atlantic,* each of approximately 2,000 cubic yards hopper capacity, and a number of smaller dredges. In 1908 the two dredges *Raritan* and *Navesink,* of approximately 3,000 cubic yards capacity each, were built for use in New York Harbor. Further need developed for this type of dredge with moderate hopper capacity and light draft which led to the building program of 1922, when orders were placed for four 1,250 cubic-yard dredges with Diesel electric equipment. The hydraulic seagoing hopper dredge fleet of the Engineer Department at present is composed of 25 dredges of hopper capacities ranging from 300 to 3,500 cubic yards and is distributed among the important harbors of all coasts of the United States.

Modern hydraulic seagoing hopper dredges are steel twin-screw vessels with molded hull and in outward appearance resemble ordinary commercial ships. In addition to their dredging equipment, they are fitted with all machinery, accommodations, equipment and appliances necessary for ocean navigation. The dredging equipment in general comprises a powerful centrifugal pump, a drag or suction head, drag hoist, hoppers or bins, overflow troughs and hopper dumping mechanism.

When the dredge reaches the bar to be dredged, the pump is started. The drags are lowered to the bottom with the pumps turning, and the ship travels over the bar at as slow a speed as is consistent with maintaining steerage way with the aid of the twin screws. Proper speeds range from ½ to 2 knots *over the bottom.* Material is loosened from the bottom by the weight and motion of the drag, and by the suction, assisted where the bottom is clayey or unduly hard by plows or scrapers attached to the drag, or, in some cases, by water jets, and is then drawn up by suction into the pumps, from which it is discharged through pipes or other leaders into the bins. The bins are provided with overflows slightly below the top of the coaming so arranged as to carry off the surplus water.

The dredge thus cuts a furrow or furrows (one for each drag) the length of her cut when, if not already loaded, she turns and goes back along the cut. These furrows are very nearly the width of the drag (from 5 to 20 feet), and in depth vary from scant 1 inch to about 6 inches, depending upon the nature of the bottom. Thus the dredge has to make many trips over the shoal, if the excavation is to be of considerable depth.

When the bins are full or sufficiently loaded, the drags are raised out of the water, the contents of the bins measured, and the ship proceeds at her full speed to the place for deposit, where the gates in the bottom of the hoppers are opened and the material is discharged.

The hydraulic type of seagoing hopper dredge has several advantages for use in bar dredging, among which are the following:

(*a*) Its ability to dredge in comparatively rough weather.

(*b*) The fact that on account of its method of operation every yard of material taken out is a definite gain to navigation, as there is a uniform increase of depth throughout the length of the area dredged.

(*c*) On account of the method of operation—that is, cutting a shallow channel over the entire length of the bar—certain assistance is gained by the natural scour produced.

(*d*) The ability of the dredge to operate in channels with no more interference to shipping than is caused by any other vessel of similar size navigating under its own power.

There are at present operated by the Engineer Department three types of hydraulic seagoing hopper dredges designated as the side-drag type, the center-well type and the stern-well type, depending upon the location of the drag or drags.

The side-drag type employing two drags, one on each side, is the type in most general use.

The center-well type employs a single drag which projects through a well located along the center line and about amidships. This type of dredge was designed to better meet the very severe weather conditions on the exposed bars of the North Pacific coast.

The stern-well type is not in general use, there being but two of this type in the Engineer Department.

The hydraulic seagoing hopper type of dredge has played a part of major importance in developing our seacoast harbors and has justified its development. Constant effort is being expended to increase the useful output of these dredges and reduce the cost of dredging. The following brief tabulation, showing the yearly record of the fleet for the last five years, would indicate that progress is being made in increasing the operating efficiency of this plant:

Year	Total number of cubic yards dredged	Average cost per cubic yard of		
		Operations	Repairs	Total
1919	18,910,059	0.12835	0.04022	0.16857
1920	19,259,144	.15466	.04213	.19679
1921	24,890,264	.10489	.01820	.12309
1922	27,207,776	.07946	.01974	.09920
1923	36,271,826	.0740	.0185	.0925

[Editors' Note.—The paper concludes with a detailed description of the four Diesel-electric dredges recently built for the United States Engineers by the Sun Shipbuilding and Dry Dock Company. An illustrated description of these vessels was published in Marine Engineering and Shipping Age for April, 1924.]

Discussion

Admiral D. W. Taylor requested the author to add the dimensions and displacement of the new dredges to the paper.

Capt. J. H. Linnard asked for particulars as to the stability of hopper dredges.

Hugo P. Frear questioned the influence of the drag on the steering of the dredge.

Capt. McEntee said he understood that the engines of these dredges had given trouble from having been operated at critical speed.

Capt. Styer, in reply, stated that torsional vibration of the Diesel engine crankshafts had given trouble, as they were not operated at the designed speed. This was being remedied by increasing the shaft diameter in the first three journals and moving the flywheels. The trouble developed around 150 revolutions per minute, whereas the engines were originally designed for a maximum speed of 140 per minute.

As regards steering, he stated that the side drags, being relatively light, gave little trouble. Center drags, though heavy, if located forward of midships, did not seriously affect steering; but the stern well type were difficult to handle, and they were building no more of this type of dredge.

As regards stability, he said that it had been found necessary to arrange for the independent dumping of each hopper compartment so as to control the heel of the vessel and that the freeboard of the dredge to be used on the Pacific coast was being increased to ensure stability when emptying hoppers.

Self-Unloading Bulk Cargo Vessels of the Great Lakes

By Henry Penton and Prof. Herbert C. Sadler

This paper will be published in an early issue.

Discussion

L. D. Smith spoke of the difficulty of converting ordinary lake cargo steamers to self-unloaders and described a new system being used by his company, the Leathem D. Smith Dock Company, Sturgeon Bay, Wis., in the conversion of certain of the old 6,000-ton vessels. The cost of these vessels when converted to self-unloaders was around $350,000, whereas a new vessel, to do the same work, would cost $750,000.

R. A. Beekman, of the General Electric Company, drew attention to the peculiar applicability of the electric drive to self-unloading vessels.

George B. Palmer: The Wyandotte Transportation Company can rightly claim to be the pioneers of the self-unloading bulk cargo ship, as it owns and operates four such vessels with an aggregate carrying capacity of 25,444 tons stone or 18,200 tons coal. The principal features of these vessels have been copied in all of the ships built since, by other companies.

In our ships we find the pan conveyor very satisfactory as it allows for the maximum cubic. Consider the case of the Wyandotte Transportation Company's steamer *Huron* (illustrated on plates 2 and 3) which has a maximum cubic for 8,000 tons. If this vessel were fitted with belt conveyors, the maximum cubic would be for 7,600 tons or 5 percent less, a loss in the earning capacity of this vessel of over 13 percent. As to maintenance, the life of the pans is about 7 years (the failure is due to corrosion not wear); whereas, the life of a conveyor belt is about three years.

I cannot agree with the authors as to any saving in weight by using electric drives, there is in addition to the prime mover the weight of the generator, the motors and the considerable gear reduction necessary between motors of a reasonable speed and the conveyor head shafts which run at a speed of about 5 revolutions per minute. The driving ends of the conveyors being concentrated at one point there is no difficulty in getting short direct drives from steam engines. As to centralized control, in our vessels the entire conveyor system is handled by a single bank of 4 levers conveniently located on deck.

Insofar as the amount of steam supplied to the engines is concerned, there should be no difference in steam consumption whether the engine is driving a generator or connected direct to the shafting. When a condensing turbine is used, the saving in steam, if any, is more than counterbalanced by electrical losses, losses due to additional gear reduction from motors and lower feed water temperature, to say nothing of more complicated apparatus and higher initial cost.

As the authors have pointed out, self-unloading ships trim by the stern, more particularly the belt conveyor type, so that it is an advantage in regard to trim to locate the conveyor driving engines forward.

We find the hinged apron hand operated discharge gate very satisfactory. In practice it is lowered to within an inch or so from the conveyor and the cargo flows in a uniform stream without flooding, and it has the merit of simplicity.

On our first ship, the *Wyandotte*, we made these discharge gates 30 inches wide. On the succeeding ships they were reduced to 27 inches which we found amply large to handle the run of mine coal and limestone sized from 6 to 8 inches that the original ship was designed for and gave better results on slack coal.

In some of the recent ships, complicated and cumbersome feeding devices have been installed, these require considerable power for operation and are frequently out of order, and there is no saving in labor.

The authors' system of elevating the floor of the cargo hold to facilitate the discharge of the cargo is certainly very ingenious. I am of the opinion, however, that it will require a great deal of power for its operation, in a ship of the cross section shown, approximately 5 tons per lineal foot to start it, and it will add considerable non-paying weight to a ship already penalized to an appreciable extent over the ordinary bulk carrier. A much simpler plan would be to increase the number of longitudinal conveyors which would add comparatively little to weight and have the advantage of more rapid unloading. I have recently completed a design for a self-unloading ship using three longitudinal hoppers and conveyors, with a capacity of 12,000 tons coal on 20-foot draft and a cargo discharging rate of 2,500 tons per hour.

I note, moreover, a slight error in the first and third paragraphs relative to the authorship of the design of this type of vessel. Without detracting in any way from the credit due to the authors for excellent service rendered the owners in the design of the hulls of the first commercial successful self-unloading cargo ship *Wyandotte* and the cement carrying ship *John W. Boardman*, the design and development of cargo holds and unloading equipment was done entirely by the engineering staff of the owners.

Henry Penton, in reply to the discussion, spoke particularly of the utilization of all possible space for cargo and stated that the movable flaps, arranged with this in view, did not require a large amount of power to operate them.

Comparison of Model Propeller Experiments in Three Nations

By Rear Admiral D. W. Taylor, C. C., U. S. N.

This paper will be published in an early issue.

Discussion

W. W. Smith stated that the agreement of the different investigators tends to increase confidence in the results of all. He did not, however, consider the ρ $\triangle$ diagram the best for practical use and submitted a chart which he had found useful in actual design work.

Prof. E. M. Bragg pointed out that all model propeller data have to be modified when applied to actual vessels. He had used Froude's data in connection with full bodied lake vessels and found the results to be uniformly too small.

Dr. W. F. Durand: The agreement of results goes far to place propeller investigation in a satisfactory condition.

Capt. McEntee considered the agreement of the different investigations remarkable in view of the widely varying sizes of the model screws.

Prof. Sadler had always looked with some doubt upon the results obtained with 4-inch model screws, and was glad to feel that confidence could be placed in them.

A. J. C. Robertson was glad that the accuracy of small model screws had been established. He thought that the higher efficiencies shown by Froude's results were probably due to the form of hub used.

Admiral D. W. Taylor, in replying to the discussion, stated that in his opinion the large power required by the lake steamers, as compared with the model results, was due to blunt edged propeller blades.

The Extent of Cavitation in U. S. Scouts and Destroyers

By Capt. Ernest F. Eggert, C. C., U. S. N.

This paper is published on page 744 of this issue.

Discussion

W. W. Smith stated that the performance of centrifugal pumps served to check the theory of cavitation.

C. P. Wetherbee drew attention to the action of struts and other similar appendages and stated that they had a marked effect upon propeller efficiency.

Admiral Taylor stated that air did not necessarily affect efficiency, as was proved by the performance of certain partially immersed propellers.

Capt. H. C. Dinger said that cavitation is not ordinarily reached in the performance of naval vessels, and drew attention to the great need of reducing appendage resistance by careful design.

The Wake and Thrust Deduction of Self-Propelled Single Screw Models

By Professor Edward M. Bragg

This paper will be published in an early issue.

Discussion

Admiral D. W. Taylor spoke of the effect upon the propeller of the frictional wake, the streamline wake and, in high speed vessels, of wave formation. He also discussed the effect of raking the blades upon the suction effect on the hull and stated that the propeller should be placed as far aft as consistent with structural conditions—that it even might be well to modify the hull form to this end.

Prof. Bragg, in reply to the discussion, stated that he had found it advisable to use torque rather than thrust in determining wake.

The Design and Construction of Refrigerated Ships

By Llewellyn Williams

This paper is published on page 713 of this issue.

Discussion

W. H. McGee questioned the advisability of using piston displacement alone as a standard for rating refrigerating machines.

C. J. Jefferson spoke of the advisability of fitting wire mesh in the insulation to keep out rats.

D. H. Cox: The Shipping Board refrigerated ships were the result of an emergency. They were the only ones available and not best suited for the purpose.

Capt. R. D. Gatewood spoke of the very great value of the paper and hoped that it might be followed by another on the refrigeration of existing vessels.

Carl E. Petersen: Too much emphasis cannot be laid upon the necessity for designing vessels so that they will form economic units in the particular service for which intended, as regards, first cost, size, speed, capacity, arrangement, structure, etc. In the case of the war-time cargo ships converted to refrigerated cargo carriers, no efforts were made to increase the boiler power so as to take care of the refrigerating machinery requirements, and apparently no thought was given to augmenting the vessels' speed, with the result that these vessels are useless, uneconomical and in lay-up at present, when good refrigerated ships are in demand.

A refrigerated ship in the intercoastal trade would carry citrus fruits eastbound and perhaps general cargo westbound, and, as the economic speed of the vessel would be greater than that of a similar non-refrigerated carrier and would approximate that of the passenger ships in this service, it would seem that the refrigerated vessel giving the largest return on the investment would be of the combination passenger and cargo type, having Diesel engines for propulsion.

J. W. Stewart, in a lengthy written discussion, submitted several drawings giving details of proposed methods of constructing refrigerated vessels on the Isherwood system of longitudinal framing.

Hugo P. Frear: The author calls attention to the fact that refrigerated ships not only cost more than non-refrigerated cargo carriers in the same trade, but have less deadweight carrying capacity. He might have added that they also have less cubic capacity for the return voyage on account of the space occupied by the insulation. It is, therefore, evident that a handicap of greater invested capital with less carrying capacity is never absent.

Alternative suggestions are offered to offset this handicap —the one being increased speed for a quick turn around, and the other, higher freight rates. If the traffic would bear an average freight rate on the cargo carried both ways, to cover all charges and return a reasonable profit on the investment, at a speed consistent with the character of the cargo, there would be no difficulty in determining the main features of the design. The economical speed would probably depend more on the freight rate obtainable than on any other single item. Speeding up the boat to make a quicker turn around would not accomplish the desired result unless accompanied by higher freight rates to cover increased cost of machinery and still smaller carrying capacity, due to added machinery weights, extra fuel, suitable model, etc.

The capital investment might be as much as 40 percent greater, as Mr. Williams says, and this increased cost might be due entirely to insulation and refrigerating machinery for a given carrying capacity. Increased speed will not only require costlier and heavier machinery, more fuel capacity, but some increase in the dimensions of the vessel for the same cargo capacity and, consequently, a further additional capital charge.

Inquiries were around a short time ago for coast to coast refrigerator steamers, of a given cubic and deadweight capacity, to make a sea speed of 18½ knots. The solution of this problem required a vessel of approximately the dimensions and power of the *American Legion* class, together with a capital investment which could apparently not be taken care of.

The freight rate might be a good point to start from before determining the design and most economical speed. The natural procedure then would be to approximate the dimensions of the vessel for several speeds and estimate which would show the greatest profit.

Mr. Williams also emphasizes the importance of designing the steel work to reduce cost of insulation, and improve final efficiency. All webs, deep beams, girders, brackets or pillars coming in way of the insulation must be boxed in. Besides increasing the cost of insulation, stowage is more or less interfered with on this account. As all ships whether refrigerated or otherwise must be strong and seaworthy, such obstructions, under the present state of the art of shipbuilding cannot be entirely eliminated. By careful attention to design aided by professional enlightenment, as Mr. Williams suggests, much can be done towards minimizing these objectional features.

While this phase of the subject is referred to in the paper broadly without reference to any particular system of framing there may be some preference in the author's mind as between longitudinal and transverse. The capital investment is greater for refrigerated ships and this, of course, includes the increase due to boxing in obstructions. The carrying capacity is also reduced on account of the weight of insulation. If the weight of insulation could be stated as a percentage of the weight of total steel in the vessel, say from 10 to 15 percent as against a saving of about 7 percent in steel for longitudinal construction, this loss in carrying capacity would be reduced by one-half and cargo earning capacity increased the same amount.

Where air circulation is not required either system of framing may be equally as efficient for refrigeration. Transverse framing on the sides is, undoubtedly, an advantage in connection with air ducts. As the air, after leaving the side ducts, circulates athwartships longitudinal framing to the decks without fore and aft girders may have its advantages. Furthermore, if, as stated, there is a load on the decks in some cases as great as 400 pounds per square foot, the decks would be much lighter if constructed with longitudinal framing.

In vessels proposed for coast to coast trade the 'tween deck spaces have sometimes been specified to be refrigerated for fruit with air circulation, and the lower hold fitted for ordinary cargo. Assuming the second deck is designed to be the bulkhead deck, the air ducts could be carried fore and aft through bulkheads in the upper 'tween decks, but there would be objection to piercing the bulkheads in the second 'tween decks. I would like to ask Mr. Williams if the invariable practice would be to fit cooling boxes and blowers in each hold for a vessel of this class or if there is any other suitable arrangement of avoiding the piercing of bulkheads which are required to be watertight.

Mr. Williams, in replying, called particular attention to the unreliability of watertight doors and the objection to piercing bulkheads by ducts—if possible, independent coolers should be used for each hold. In regard to the form of hull construction used, he was of the opinion that for air circulation ships, the transverse system offered advantages, but that for frozen or chilled meat cargoes either transverse or longitudinal framing could be used. It was necessary that hull details should be carefully designed, having in view the insulation and the character of stowage of the refrigerated cargo. Speaking of thermometers, he said that, while certain electrical instruments, as originally fitted, were not satisfactory, by proper design they had been made to operate well and gave good results. He would not use automatic recording thermometers on any refrigerator vessel.

Application of Fuel Conservation and Engineering Performance Standards of Shipping Board Vessels

By Carl J. Jefferson

This paper will be published in an early issue.

Discussion

G. Bartlett*: It might be well to outline briefly what is done with the efficiency reports when received by the operator and the use that he can make of them, and then to mention a few suggestions that the port staff and chief engineers, who are in daily contact with this work, have to offer.

Three copies of the voyage report are received by the operator; one is held in the office for office use, one is sent to the master of the ship and the third to the chief engineer with such instructions as may be necessary in addition to the comments already contained in the report. The data on the office copy is transferred to a form which shows the comparison of the data with previous reports. At the bottom of this form two curves are plotted, one showing the efficiency for each passage, and the second showing the efficiency over all voyages to date. This latter curve is of value in showing at a glance any consistent gain or loss in efficiency. The same form is given to the chief engineer of the ship and he is required to keep his up to date, getting whatever assistance may be necessary from the office.

For each different type of ship, that is, Federal, Hog Island "A", etc., the efficiency-percentage-to-date curves are drawn on another form to the same set of coordinates. This form shows clearly a comparison between ships of the same type. A study of the curves, together with consideration of the different types of auxiliary equipment on the ships, and also the personnel, is of great benefit in locating the faults of those ships that show continued poor performance.

The inauguration of the Shipping Board voyage reports on fuel conservation, together with the establishment of the Fuel Oil School at Philadelphia, has resulted in a tremendous amount of interest among the operating personnel in burning oil efficiently and has produced intense rivalry among the masters and the chief engineers, particularly on the same type of ship. The master and the chief engineer have access to all data in the office and frequently consult the figures, etc., of the other ships to see why the other ship is beating them out. The plan has also tended to promote cooperation between the master and the chief engineer and the whole subject of fuel economy is brought more forcibly before the attention of the master and gives him an additional incentive to see that a steady course is steered and that no fuel is wasted in steaming unnecessary distances.

The establishment of the port fuel record is a necessary adjunct of the sea performance records as there is always a tendency among engineers to cover up under port consumption some fuel that is actually consumed at sea. Now that they are being accurately checked on both performances there is no temptation for this practice.

In any system for the conservation of fuel oil on ships, the personnel on board is of extreme importance and must be educated up to what is expected of it. The following suggestions from the shore staff and chief engineers of the ships may be helpful:

(1) The standard of performance expected for the various types of ships does not appear to be uniform. This, in many cases, is discouraging to some chief engineers who often obtain a low rating although they are doing the best they can with the equipment in hand, and instances have arisen where engineers have been transferred from one ship to another, of different types, with a corresponding loss in their efficiency rating in the voyage report. This also applies to port consumption standards.

(2) It would be extremely helpful to the operators if the average efficiency to date on all Shipping Board ships of a particular class could be furnished at frequent intervals, or if the record of the best performance, in any class, could be published from time to time. This would show the personnel what ships in other companies were doing and would tend to broaden their interest in the whole subject.

(3) In rating the personnel on efficiency the inspector should be careful to give the engineers full credit, if they are doing everything that possibly can be done with the equipment available; also in marking the physical condition of machinery care should be taken not to penalize the personnel, if the apparatus is merely undergoing ordinary minor repairs by the ship's crew. In other words, every effort should be made not to destroy the interest and confidence of the engineers in the system being followed.

(4) In the formula for port efficiency the value of K1 is the same for practically all types of cargo vessels. It is, however, thought that some allowance should be made in this figure on ships when it is necessary, in winter time, to keep steam on the deck lines to prevent freezing.

The allowance of fuel under K2 for handling cargo is given the same for all cargo ships. This allowance should vary with the type of winches, and also should be changed when any improvement is made in the cargo handling machinery.

In computing the pounds of fuel consumed in port, allowance must be made for fuel consumed in shifting to and from dry dock or to another loading berth. As this is sometimes overlooked, a term expressing this allowance should be included in the formula in order to make same complete.

(5) It would be very helpful to the chief engineers if they could have the reports and comments on the preceding voyage before sailing, as otherwise the data and comments are several months old before they see them.

(6) It would be a great benefit to all engineers if the Fuel Oil School could issue bulletins from time to time, showing briefly the work that is being carried on there and the results of tests on various kinds of equipment, etc. This would be in the nature of a post-graduate course and would keep up the interest of the men in the school and keep them posted on what was going on.

In conclusion we wish to repeat that the whole system of fuel conservation is a decided success as the records plainly show.

Carl E. Petersen: Quite distinct from the very marked economies in fuel, lubricants, repairs, etc., effected in the operation of the Shipping Board's fleet, the education of the operating personnel is of especial significance to the entire merchant marine, in that the benefits resulting therefrom will accrue to shipowners for years to come. It is an axiom, that the highest efficiency is obtained from personnel when suitable and adequate rewards are offered as inducement for greater effort. For this reason, the recent action of the Fuel Conservation Committee in offering the preference of berths on the vessels to be converted to Diesel propulsion, to the engineers of vessels attaining the highest efficiencies, is to be commended.

Professor Evers Burtner*: Under port performance

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*Massachusetts Institute of Technology, Cambridge Mass.

I note that the port consumption of the winches was based in part on the power required to handle cargo by electric winches. It would be very interesting if the results of Mr. Jefferson's tests on the electric winch equipment were published.

Mr. Jefferson, in reply, explained the method followed in sounding tanks to determine the amount of oil contained, and said that the work described in his paper had only been possible as the result of the cooperation of the operating personnel on board ship.

Scrapping Warships

By Commander H. E. Rossell, C. C., U. S. N.

Abstract

After the World War, both Great Britain and the United States started to discard obsolete warships. These vessels were sold from time to time for scrap, and several wrecking concerns undertook the task of cutting them up for the salvage value of the metals they contained. The Disarmament Treaty signed August 17, 1923, provided for the demilitarization of a large number of modern war vessels within a period of six months from the signing of the treaty, and for the total demolition of these ships within a period of a year and a half from that date. The nations involved were confronted with the problem of disposing of these vessels to the best advantage, and they naturally turned to the firms which had had some previous experience in scrapping ships.

In this country it was found that the information at hand was extremely meager as to the best methods to employ in scrapping warships. The concerns in this country which had had experience in cutting up our obsolete warships had encountered great difficulty in executing this work. These concerns had apparently sustained considerable losses on the previous ship scrapping and were willing to offer only very small sums for the modern vessels to be destroyed in accordance with the terms of the treaty. The Navy Department therefore decided to have the scrapping of five ships afloat, and the scrapping of four uncompleted ships on the building ways done by navy yards. The scrapping of the remaining vessels covered by the naval treaty was assigned to private contractors.

The metal from vessels scrapped in navy yards was sold with the understanding that it would be cut to any size acceptable to the railroad. Some of the private firms engaged in shipbreaking sold the material cut to charging box size.

In scrapping warships, the generally accepted means of cutting ferrous materials, including armor, is the oxy-acetylene torch. Some use has also been made of hydrogen as a substitute for acetylene, but it is doubtful whether this substitution results in economy. The carbon arc may be used successfully to cut brass, bronze, copper and cast iron, but it is not economical for cutting steel of the thickness encountered in warships. The glare of the arc is extremely disagreeable to workmen in the vicinity, and the power leads required for the arc are heavy and expensive. It is not generally appreciated that in scrapping work the cost of oxygen and acetylene amounts to as much or more than the labor cost for the torch operators. If the gases are used in flasks, the cost of handling these flasks and the wasted time of torch operators due to moving torches from flask to flask are items of considerable importance.

Unquestionably, the most important problem to be solved by the shipbreaker is the economical use of the oxy-acetylene torch. In this connection the following points are mentioned:

1. The type of equipment to be used should be standardized.
2. The tendency on the part of most torch operators is to use excessive gas pressures. This practice perhaps results in a slightly greater speed in cutting, but the resulting labor saving is much more than offset by the increase in the gas bill.
3. Operators should be required to promptly return to the tool room any defective equipment.
4. A close watch should be kept for leaks in gas lines and in gas equipment, and any leaks found should be promptly repaired.
5. Even if only one battleship is to be scrapped, it would probably pay to lay down oxygen and acetylene pipe lines and to install an acetylene generating plant rather than to use the gases from flasks.
6. It is mistaken economy to employ low-grade torch operators.
7. Warships usually have many coats of paint over all surfaces. This paint is a great hindrance to economical cutting, and is also a menace to the workmen, especially the torch operators. In confined spaces, it is economical to have men scale off the paint along the lines to be followed by the torch operators.
8. Even when scaling of paint is done extensively, trouble with lead poisoning is likely to be encountered. To guard against this disease, all torch operators should be provided with respirators
9. The cutting speed below decks is so low that it is of the greatest importance to so regulate the work as to provide the maximum of ventilation for the torch operators. This consideration is likely to be the governing one in laying out the general scheme of cutting and in deciding upon the handling facilities required.

A crane of capacity of at least 50 tons should be available for scrapping battleships, and a capacity of double this amount is of great advantage. If the method of cutting a ship in large pieces is to be followed, considerable ground space must be provided upon which to place the large pieces preparatory to cutting them up into shipping sizes. This space must be provided with quick-working cranes of small capacity, suitable for loading the material into cars for shipment.

One of the most troublesome jobs in scrapping a ship is to remove the wooden decks. The method used at the Philadelphia Navy Yard consists of removing nuts from deck bolts with pneumatic chipping hammers and with socket wrenches having crank-shaped handles. The pneumatic tools are used to clear away interferences and to remove nuts where difficulty is experienced in handling the wrenches. Laborers are used to remove all interferences and to remove the nuts and knock the bolts up through the deck. About 400 to 500 nuts are removed and the bolts knocked up daily by each man employed. When the deck bolts have been knocked up in this manner, the planking is pried up by means of crowbars, wedges and sledges. The total labor cost for removing decking by this method is about 30 cents per square yard.

One shipbreaking concern uses the last method described above except that deck bolts were punched down from the top side by means of a hand punch and sledge. Another shipbreaking concern used the same method except that a drilling machine having an extension socket wrench attached to its spindle was used to back off nuts from the deck bolts.

The removal of armor from a war vessel also presents many difficulties. After standard methods have been developed, however, the armor can be removed rapidly and cheaply. Wood-backed turret and side armor may be cheaply and quickly removed by cutting by the torch through the steel and wood backing in way of armor butts and seams. The wood backing can be burned through after the steel backing has been cut by first getting a slight heat on the wood with the oxy-acetylene flame and then turning off the acetylene. When the armor has been cut adrift in this manner, it may be lifted ashore and the securing bolts may then be removed by the use of pneumatic tools and large wrenches or by use of the torch. This method of removing the armor is open to the objection that a large percentage of the teak backing is destroyed. Unless a very large price is obtained for this teak, however, the savings effected in handling the armor and in removing the bolts more than offset the loss of the teak.

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Some concerns remove turret and side armor plate by plate by backing out the securing bolts and cutting securing angles and other structural work. When this method is used, lifting pads must be fitted to each piece of armor before it can be removed from the ship.

On the older battleships the barbette armor was not keyed. Such armor can be removed, after the surrounding structure has been cut away, by merely cutting the armor butt straps and the angle connections and then lifting the armor off plate by plate.

In cases where the barbette armor is keyed together, its removal offers greater difficulties. One method followed at the Philadelphia Navy Yard consisted of cutting one armor butt strap on each side of the barbette and forcing one-half of the barbette away from the other half with hydraulic jacks. The Philadelphia yard also removed keyed barbette plates after seam straps and other connections had been cut by lifting each plate directly up, the keys slipping in the keyways. This method is not recommended unless a crane of very great capacity is available.

If the capacity of the crane available is sufficient, 8-inch turrets may be removed as a unit, and 12-inch turrets may be removed after they have been stripped of armor, guns, and gun slides. The cutting up of turrets in place on the ship is very much more expensive than the carrying out of this work on the ground, due to the impracticability of providing adequate ventilation in the turrets on the ship.

When material is cut to shipping sizes, difficulty is likely to be experienced in securing minimum carload weights unless care is exercised in cutting and stowing the material. It is desirable to have very light material disposed of by throwing a little of such material in almost every car rather than by trying to make up carload lots out of such material.

The shipbreaker is likely to be disappointed in the value of usable material which he is able to salvage from a battleship. The nature of the scrapping work is such that damage is done to practically every article on the ship before it is removed. Aside from this difficulty, much of the material will be found to be of special design and not suitable for commercial purposes. A navy yard is in a more advantageous position than a private concern in finding use for material removed from battleships being scrapped. It is possible in many cases to substitute such material on naval vessels instead of purchasing new material of a similar nature.

Non-ferrous metals, such as brass, bronze, lead, zinc, babbitt, etc., have, of course, much greater value than structural steel or armor, and it is necessary to take special precautions in removing these metals and in segregating them in such manner as to realize the greatest financial return from them. Battleships, especially the older ones, contain large quantities of non-ferrous metals, some of which can be removed easily, and some of which will cost more to remove than its value.

The Philadelphia yard now uses a separate gang of men who work well ahead of the torch operators in knocking down all such metals as can be removed without the use of the torch. No attempt is made to remove the metals from the ship until the surrounding structural material has been taken out of the way. When this has been done, non-ferrous metals are placed in large trays and are sent to a building, a certain portion of which is devoted to the storage and segregation of the metals.

Ship scrapping is inherently dangerous. In generating, handling, piping and using oxygen and acetylene, all precautions recommended by the underwriters and by the manufacturers of oxy-acetylene equipment should be strictly enforced. Adequate provision should be made to guard the ship being scrapped and surrounding property against unnecessary fire hazard, and fire-fighting equipment should be available to handle any incipient fires which may occur.

The last portion of the ship, consisting of the bottom plating, inner bottom and small part of the sides, may be disposed of—

1. By drawing it up on the beach at high tide and cutting it up at low tide.
2. By sinking it in a location where its presence would not be objectionable.
3. By hauling it up on building ways and then cutting it up.
4. By placing it in drydock and cutting it up.

The method to be followed will, of course, depend upon the facilities available.

In scrapping uncompleted ships on the building ways, the same general methods are used as for ships afloat. Usually, however, there are not nearly as many interferences encountered on ships on the ways, and the handling facilities available are usually much cheaper to operate.

The Navy Department sold at very good prices all of the material from the battleships being scrapped at the Philadelphia Navy Yard. The material is being shipped out as soon as it is removed, without the necessity of storing it.

It is understood that some of the difficulties of private concerns engaged in shipbreaking in recent years may be attributed to poor judgment in disposing of the material removed from the ships.

The elements entering into the cost are so numerous and complex and vary so with local conditions and accounting practices that one naturally hesitates to make a general statement as to what the cost of any particular project should be. The writer has heard estimates from various sources as to the cost of scrapping ships afloat and ships on the ways. These have ranged from $6 to $15 per ton of material shipped for ships afloat and from $2.50 to $6 per ton of material shipped for unpainted ships on the ways. The writer has also heard estimates of $2 to $3.50 a ton for cutting structural steel from shipping to charging box size.

The following labor and material costs represent the experience of the Philadelphia yard in cutting to shipping sizes and loading on cars about 6,000 tons of unpainted structural material erected on the building ways, and about 10,000 tons of armor, 13,000 tons of structural material and 350 tons of non-ferrous metals from ships afloat. Crane and dock rental charges and overhead expense have purposely been omitted, but the costs include all direct labor, power, fuel and other materials used. The costs do not include the installation of pipe lines, generators, tracks or other capital charges.

Ships on the ways (unpainted)	*Cost per ton*
Cost of oxygen and acetylene	$1.00
Loading and switching charges, handling gas tanks, crane operators, power	.40
Labor for cutting and laying out cuts	1.00
Total labor and material per ton shipped	$2.40

Ships afloat (painted)	*Cost per ton shipped*
Oxygen and acetylene	$2.30
Transportation, crane operators, light, steam, air, power, staging, truck service, tug hire, moving vessels	.55
Cutting, removal and loading of ferrous metals, removal of interferences such as wood, cellulose, decking, etc	3.95
Total labor and material per ton of ferrous metals shipped	$6.80
Removal, segregation and loading non-ferrous metals	$20.00

DISCUSSION

CAPTAIN W. P. ROBERT, C. C., U. S. N.: While this paper contains valuable data as to methods to be followed in the scrapping of ships and in gas cutting operations in general, its foremost value will, it is believed, be found in the object lesson on organization that is presented. I believe every industrial establishment should have careful provision of one kind or another for "preparation" for the work. This paper shows that the idea of *preparation* has been constantly in mind to further results and to reduce costs and has operated towards both of these objects.

LIEUTENANT GEORGE J. SHAW, C. C., U. S. N.: Following the Limitation of Armament Conference, held at Washington, D. C., and the signing of the Treaty on August 17, 1923, the Secretary of the Navy authorized the Bureau of Supplies and Accounts to offer for sale certain battleships belonging to the U. S. Government. The battleships *South Dakota* and *Indiana* of 42,000 tons each, under course of construction at the Navy Yard, New York, were among those to be sold, on an "as is" basis. The *South Dakota* was 36 percent and the *Indiana* 33 percent completed. On October 25, 1923, the two above-named vessels, among others, were offered for sale, and the highest bid offered for the purchase of the two vessels, on the stocks, was $66,580. This bid and all other bids were rejected by the Navy Department, and orders were issued by Admiral Plunkett for the Navy Yard force to proceed with the work of scrapping.

The preliminary work of scrapping these two ships was commenced on November 13, 1923, and, on December 9, the first shipment was made. The work was completed on July 16, 1924. The total time required for the completion of the job was 205 actual working days. During this period, the average number of men employed on this job was twenty.

The output by months was as follows:

Month	Gross Tons	Monthly Charges	Sales Value
December	2,834.4286	$8,697.52	$26,955.42
January	2,415.8214	6,236.76	22,974.46
February	2,832.3214	6,138.02	26,935.38
March	3,752.5714	7,703.12	35,686.95
April	2,801.7142	8,129.38	26,644.30
May	2,365.5089	9,160.04	22,495.99
June	3,058.5446	8,262.91	29,086.76
July	1,705.3258	4,989.60	16,217.65
	21,766.2363	$59,317.35	$206,996.91

An analysis of the cost of this work and a comparison with the bids received shows the following:

(a) Gross Charges:

Labor	Indeterminate	Material	Total
$30,349.55	$11,735.67	$17,232.13	$59,317.35

(b)	
Unit cost per gross ton:	$2.72
Total amount received:	206,996.91
Net proceeds (profit):	147,679.56

The net proceeds, amounting to $147,679.56, compared with the two high bids referred to above, shows that the Government gained $81,099.56 by awarding this work to the Navy Yard instead of selling these vessels on the stocks at a price of $66,580. On the other hand, the Government gained $71,996.91 as against the acceptance of the lump sum bid of $135,000 referred to above.

There were no casualties among the working force, except two minor cases. No cars were damaged or demurrage assessed, and 630 cars were required to move the material.

H. G. **SMITH** asked if overhead charges had been included in the costs given in the paper and also inquired as to the increased cost if the navy yards had reduced their scrap to charging, instead of shipping, sizes.

CAPT. H. C. **DINGER** spoke of the importance of safety precautions when scrapping steel vessels. The possibility of extensive scrapping of Shipping Board vessels made the paper one of particular interest. He advised that this scrapping should be done gradually in order that fair scrap prices might be maintained.

COMMANDER ROSSELL, in reply to the discussion, stated that all overhead expense had not been included in the costs, but that all direct material and labor, transportation, staging, power, light, crane operators and tug hire were included.

Trials and Operation of the Motorship Cubore

By Arthur B. Homer

ABSTRACT

This ship was built by the Fore River Plant of the Bethlehem Shipbuilding Corporation, Ltd., and was delivered August 3, 1920. The hull is of a design suitable for the iron ore and coal trade, with the machinery located aft, and of the following characteristics:

Length overall	468 feet 2⅝ inches.
Length between perpendiculars	450 feet 7 inches.
Breadth, molded	57 feet 0 inch.
Depth, molded	37 feet 0 inch.
Draft, loaded	27 feet 6 25/32 inches
Block coefficient, loaded	0.80
Displacement, loaded	15,992 tons.
Deadweight tonnage	11,000
Speed	10 knots.
Propeller	diameter 16 feet 6 inches, pitch 11 feet. developed area 82.5 square feet. projected area 76.2 square feet.

The interval between the delivery of the *Cubore* and the writing of this paper may be divided into two distinct periods. The first period covers the operation of the *Cubore* with her original[1] machinery installation, together with the experimental and development work conducted during that time. The second period includes the operation of the *Cubore* after the reconditioning of her machinery.

First Period.—The main engine was of the Bethlehem design of the two-cycle, single-acting, head scavenging, air-injection type of the following characteristics:

Shaft horsepower	2,400
Revolutions per minute	100
Number of cylinders	6
Bore	25.5 inches
Stroke	48 inches

The auxiliary machinery consisted in part of:

2—100-kilowatt Diesel generators.
1—100-kilowatt turbo-generator (steam).
1—Scotch boiler, 12 feet 6 inches diameter by 11 feet length.
1—combined condenser, air and circulating pump, 12 inches by 14 inches by 14 inches by 12 inches (steam).
2—starting air compressors—duplex, 2 stage, 350 pounds, 11¾ inches by 5 inches by 10 inches.
1—booster air compressor—duplex, 1,200 pounds, 1¾ inches by 6 inches.
1—donkey boiler, vertical, 3 feet diameter.
1—steering gear, screw type, 35 horsepower motor.
Steam capstan, windlass and winches.

The construction of the engine placed in the *Cubore* constituted the first efforts of the Bethlehem Steel Corporation in the development of their own two-cycle Diesel oil engine.

For two years the *Cubore* was operated between Cuba and Chile with her home port at Sparrows Point, Md. During this period many experiments were conducted under actual operating conditions, and improvements in design were carried out and approved for future engines, with every effort being made to produce an engine suitable throughout for continuous and severe sea service.

At the time of the installation of this large single unit in a ship, there existed a general sentiment opposed to single-screw motor ships. The operation of the *Cubore* has justified the faith placed in this type of engine, and has given ample evidence of the reliability and advantages of the single-screw Diesel engine as designed for installation in cargo vessels.

The general construction of bedplate, frames, cylinder supports, cylinders, fuel and scavenging valves, pistons, crossheads, connecting rods, and crank-shaft was found satisfactory, and improvements have only been made in the

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choice of materials and in the refinement of details to provide greater durability and accessibility.

The accessories of the engine, such as the injection air compressor and scavenging pumps, have undergone a radical change from the original, in order that a simpler, more compact and reliable arrangement might be obtained.

The introduction of cast steel in place of cast iron and forged steel led to some very interesting results. Three, one-piece, two-throw sections, two made of cast steel and one of forged steel, made up the crankshaft of the *Cubore's* engine. The cast steel sections were used as the center and after sections in order that they might be subjected to the greatest stresses. While the forged steel section was about one inch larger in diameter than necessary, due to its being made the same size as the cast steel sections, it might be of interest to note here that the forged steel section cost 64 percent more and weighed 27 percent more than the cast steel section. The forged steel shaft required 84 percent more machine hours to finish than the cast steel shaft required. All original sections of crankshaft are still in the *Cubore* after five years of satisfactory operation. Connecting rods, with I-section, and crossheads also were made of cast steel and have been satisfactory.

Second Period.—Such progress had been made during the experimental period mentioned above that the decision was made to reconstruct the original engine, which had served its purpose so well. The opportunity was also taken to improve the machinery arrangement, so that the entire installation might conform to present-day practice, without going to too extensive and costly alterations. This work was completed in January, 1924.

The general changes to the main engine have previously been dwelt upon. The bore of the cylinders, however, was increased from 25½ inches to 26 inches, the present standard size for this engine. The fundamental design of the engine was satisfactory and remained unaltered, so that the chief changes were in the design and drive of scavenging pumps and air compressor, and in the refinement of valve gear, fuel pump, and reversing mechanism.

The auxiliary machinery underwent considerable change, greatly improving the appearance of the engine room and providing a much more economical installation. Originally part of the engine-room auxiliaries were steam driven and part electric motor driven, while all the deck machinery except the steering gear was steam driven. On account of the rapid development in the past few years of electric deck machinery, and with additional proof of its reliability, the entire steam plant in the *Cubore* was removed and electric motor driven auxiliaries installed.

The boiler was a constant source of annoyance, steam having to be kept up at sea for standby purposes. The following average fuel consumption figures obtained from several round trips to Chile with and without the steam auxiliaries illustrate the saving in fuel when using electric auxiliaries. It should be borne in mind that the deck machinery is not used for either loading or unloading the cargo.

	With steam auxiliaries	*With electric auxiliaries*
At Sea—Boiler	407 bbls.	... bbls.
Auxiliary Diesel generators	129 bbls.	147 bbls.
In port—all auxiliaries	121 bbls.	16 bbls.
Total	657 bbls.	163 bbls.
Saving		494 bbls.

There follows a partial list of the engine-room and deck machinery now in the reconditioned *Cubore:*

3—100 kilowatt Diesel generators.
2—starting air compressors, duplex, 2 stage, 350 pounds, 11¾ inches by 5 inches by 10 inches.
1—booster air compressor, duplex, 1,200 pounds, 3¼ inches by six inches.
1—emergency air compressor unit.
1—donkey boiler—vertical, 3 feet diameter.
1—steering gear, screw type, 35-horsepower motor. Electrical windlass and winches.

Since going into service on February 12, 1924, the *Cubore* has been operating continuously, having run to date, August 11, 1924, a distance of 37,450 nautical miles in an elapsed time of 182 days, including loading, unloading, and all delays in port or for Panama Canal passages. Table I gives the elapsed time for the various voyages and passages. Only 10.7 percent of the total elapsed time of these voyages was spent in port, and, when it is considered that while loading in Chile the engine must be on "stand-by," the round voyage of about 37 days becomes practically continuous as far as the machinery is concerned. The remaining 8.5 percent port time of the total elapsed time is more than ample for keeping the propelling and auxiliary machinery in first class operating condition.

TABLE I

Voyage	Distance, Round Voyage	Elapsed Time, Days Out-bound	Load-ing	In-bound	Unload-ing and Fueling	Total	Sum Out and Inbound
1 Baltimore-Cuba	2,509	5.03	1.84	5.57	4.36	16.80	10.60
2 Baltimore-Chile	8,739	17.66	.28	19.05	2.28	39.27	36.71
3 Baltimore-Chile	8,743	18.22	.39	18.60	4.52	41.73	36.82
4 Baltimore-Chile	8,731	18.85	1.05	18.37	3.74	42.01	37.22
5 Baltimore-Chile	8,728	17.75	1.95	19.40	3.33	42.43	37.15
Totals	37,450	77.51	5.51	80.99	18.23	182.24	158.50

Table II gives the totals and averages of sea performance for each of the round voyages to Chile, not including Panama Canal passages. The true value of this data is only apparent when it is reduced to a basis in terms of cargo-carrying capacity. Taking into consideration the actual cargo carried, the distance run, and the fuel consumption, the results show that 1,000 tons of revenue cargo can be carried 100 miles on a total fuel consumption for all purposes of 3.185 barrels of 22 degrees Baumé fuel oil.

TABLE II

	Sea Passages—Round Voyage			
Voyage number	2	3	4	5
Time, hours	822.7	795.8	831.0	826.9
Distance, observed	8,366	8,371	8,361	8,354
propeller	8,929	8,746	8,934	8,921
Speed, knots	10.17	10.6	10.06	10.1
Slip, percent	6.4	4.3	6.3	6.2
R. P. M	100.0	101.2	99.1	99.4
Av. I. H. P.	3,385	3,408	3,370	3,390
Av. S. H. P.	2,430	2,468	2,415	2,434
Fuel consumption per day:				
Baumé gravity—fuel oil	22	22	22	24
Main engine—barrels	79.6	80.4	79.5	82.0
Auxiliaries—barrels	3.4	3.7	4.1	4.0
Total barrels	83.0	84.1	83.6	86.0
Total, tons	12.0	12.1	12.0	12.1
Fuel consumption—main engine on 19,000 B.t.u. lb. basis:				
Lbs. per I.H.P. hr	.313	.313	.313	.314
Lbs. per S.H.P. hr	.435	.434	.437	.436

As the Ore Steamship Corporation has a number of steamers about the same size operating on exactly the same schedule and conditions, the following comparison, Table III, gives an idea of the economy that is actually obtained through the use of the internal-combustion engine:

TABLE III

	Round voyage—sea averages Steamers Reciprocating	Turbine	Diesel
Time, hours	865	870	819
Distance, observed	8,428	8,336	8,363
Speed, knots	9.75	9.58	10.23
Slip, percent	11.32	8.77	5.65
R. P. M.	68.5	80.9	100.0
Fuel consumption per day:			
Total, barrels	226.0	215.1	84.17
Total, tons	34.3	32.66	12.05
Barrels 1,000-ton cargo, per 100 miles	8.18	8.00	3.185

Port fuel oil consumption averaged about 80 barrels per day for the steamers as against 4 barrels per day for the Diesel.

Discussion

Capt. Dinger called attention to the fact that the *Cubore* had the first Diesel engine, of exclusively American design, to be installed on a seagoing ship. He noted the departure from previous practice in the use of cast steel for certain parts of the engine, and inquired if any ill-effects had resulted from the use of salt water for cooling purposes.

Spencer Miller inquired as to the cause of certain apparent discrepancies in the times given for loading and discharging the cargo.

J. L. Bogert drew attention to the low pitch ratio of the propeller and inquired as to what propeller efficiency was obtained.

Mr. Homer, in replying to the discussion, gave the following particulars of the propellers of the vessels mentioned in Table III of his paper:

Type of Machinery	Diameter	Pitch	P/D	Propulsive Efficiency
Steam-Reciprocating	18′ 0″	16′ 3″	0.903	0.600
Steam-geared turbine.....	17′ 6″	13′ 3″	0.758	0.632
Diesel	17′ 0″	10′ 9″	0.633	0.578

He stated that salt water cooling had proved entirely satisfactory. With sea water at 80 degrees, the cooling water discharge temperature was from 105 degrees to 110 degrees, considerably below that at which deposits would occur.

The variation in times of loading and unloading was due principally to the hour of arrival at the dock and the necessity of sometimes shifting the vessel to get fuel, all of which was included in the time in port.

Problems in Connection with Conversion of the Hog Island Steamer Seekonk to a Motorship

By J. C. Shaw

Abstract

Before the conversion of the *Seekonk* was undertaken there had been much discussion in reference to the desirability of converting some of the government-owned, war-built fleet into motorships, but very little had been done to carry this into effect.

Reasons for Selection of Hull.—The selection of the Hog Island type of vessel was for various reasons. It was considered among the best that had been turned out by the Emergency Fleet Corporation, being both strong and well built. The size also made it easily adaptable to a single-screw Diesel drive with minimum hull alterations. These vessels have good under-water lines and are fairly easy to drive.

From the performance of several sister ships it was ascertained that the average speed of the Hog Island vessel in service was actually from 10 to 10½ knots, and it was accordingly decided to power the *Seekonk* sufficiently only to equal this mean speed. From the effective horsepower curve it was estimated that 2,300 Diesel indicated horsepower, or 1,800 shaft horsepower equivalent, would be sufficient for this speed, and which has been confirmed in service.

The engine is of the Cramp B & W 4-cycle single design and has six cylinders of 29⅛ inches diameter and 59-inch stroke, and designed to give 2,300 indicated horsepower at 85 revolutions per minute.

Auxiliaries.—In the carrying out of the conversion it was decided there would be no compromise made, as is sometimes done, in trying to keep down the first cost of the installation by retaining steam drive for any of the auxiliaries. It was believed that the additional money involved would be well compensated for by having a motorship in every way modern and capable of competing on an equal basis with new motorship tonnage under construction in foreign yards.

The engine-room auxiliaries are entirely new and of special design, which reduces their number and space occupied to a minimum. Where standard auxiliaries are purchased in the open market, the tendency is to use a much larger number to fulfill all requirements, which complicates operation unnecessarily and crowds the engine-room space.

The most important auxiliaries have been placed on the same side of the vessel as the operating stand of main engine, and convenient to the engineer on watch.

The auxiliary engines are also a new design and similar in cylinder construction to the main engine. They have two cylinders each, with a bore of 12 3/16 inches and a stroke of 13¾ inches, and each is rated as 100 brake horsepower when turning at 400 revolutions per minute.

Each engine drives a 65-kilowatt direct current generator, supplying current at 220 volts, and an oversize compressor. By means of a change valve, controlling the clearances in the air cylinders, each engine can be made to supply extra air for maneuvering purposes. They also can supply injection air to the main engine should its compressor be out of commission.

The combined fire, bilge and sanitary pumps, ballast pump, and fuel oil transfer pump, are driven by a common size motor of 15 horsepower rating, and the combined lubricating oil and circulating water pumps by 25 horsepower motors. All engine-room motors are enclosed and waterproof, and fitted with ball bearings, which reduces the attention required for them to a minimum.

A new line shaft was installed, increasing the diameter from 12⅝ inches to 13¼ inches to meet the classification society's rules. This necessitated new line shaft bearings, which were increased one in number, and with some of their positions relocated.

The old tail shaft and stern tube bearing were retained, requiring no changes.

The thrust bearing is new, being of the single collar design and lubricated from the main lubricating system.

A new propeller of one foot less diameter, and solid, was installed in place of the old propeller, which was built up. This was done to suit the smaller designed horsepower and to take advantage of any increase in propulsive efficiency that might be had with a solid wheel.

The steerer is new and of the hydro-electric type, the only old parts that were kept being the hand wheels of the hand steerer. The telemotor is the same, which was relocated to suit the new steerer.

The winches are a new design and built by the Cramp Company, being based on considerable experience gained by them with winches on the previous motorships, ***William Penn, Californian*** and ***Missourian***. The winches of these earlier vessels were equipped with 30-horsepower motors and designed for 5,000 pounds on the first gear and 10,000 pounds on the second gear. Operating experience showed, however, that the larger lift was never employed on the single line by the stevedores, due to the risk involved. It was also found that the greater percentage of lifting was less than 1½ tons, and to be able to lift up to 5,000 pounds on first gear was unimportant. The new winch, accordingly, was designed for the same hoisting speed as the larger winch up to 3,500 pounds on the single gear, and to only 3 tons maximum on the second gear. On account of having a smaller WR^2 in the armature and being able to dispense with the small amount of compound winding in the field, which was necessary with the larger motor, the lowering speed is faster for the smaller winch, and which increases progressively with the hook load. At 1,500 pounds load, which is the average load handled, the smaller winch has actually 100 percent faster lowering speed.

In addition to speeding up the cycle of the cargo handling, the 20-horsepower winch is proportionally smaller, and, due to its correspondingly greater regenerative effect, tends to keep down the size of the power plant required, which is an important factor.

The motor is of the waterproof type, with special impregnated asbestos insulated windings to withstand high deck temperatures. The control is manual, with cam type contractors, which have been found to give minimum trouble in service.

The expenditures that may be required to recondition a vessel that has been laid up for an extended period is the uncertain factor in connection with conversion work. The amount of work that might be necessary is very indeterminate and varies widely with each vessel, depending on its particular condition. This was illustrated with the *Seekonk,* in which there was much work done which could not be foreseen, as, for instance, the double bottoms contained a great deal of heavy oil deposits, which had to be removed by hand, which was slow and expensive.

There was work done on the hull which might be considered not entirely necessary but which was very desirable for putting the vessel into first class condition and in keeping with the new type of machinery.

No extensive hull changes were required to accommodate the new machinery. The screen bulkhead was removed from between engine room and boiler room, as well as the coal trunk and lavatories in the way of the hatches. The space on sides between decks, occupied by the uptakes, was thrown into the cargo space by the closing up of these openings.

The cubic capacity, measured in bales, was increased from 373,200 cubic feet to 382,200 cubic feet, or a difference of approximately 9,000 cubic feet. The gain was below the main deck and does not take into account the increase in deck load due to having the winches elevated on platforms.

It is estimated that the deadweight cargo capacity has been increased about 1,000 tons for the usual voyage.

There are six less men in the engine-room crew of the motorship *Seekonk* than on corresponding steam-driven sister ships. On the motorship there is a chief engineer, four assistant engineers, one electrician, and four motor men. On the steamers there are carried the same number of engineers and three oilers, three water tenders, three firemen, and two wipers, making 15 in all, as against nine for the motorship.

The results obtained with the *Seekonk* operating as a motorship check closely the original estimate for economies.

In good weather, and loaded, the vessel makes approximately 10.5 knots with the propeller turning 86 revolutions per minute and main engine developing 2,300 indicated horsepower. The power developed is very uniform, due to the mean indicated pressure being kept as near as possible to 90 pounds per square inch.

The averages of the first three voyages are given in the accompanying table. The voyages are to the Pacific Coast and return, starting at Baltimore and calling at the principal coastwise ports.

The total mileage at sea, or between pilot stations, is 38,585 nautical miles, and about 2,500 miles run in rivers, harbors, etc.

The total time at sea was 157 hours, and in port and running in harbors, rivers, etc., 140 hours.

Voyage	*First*	*Second*	*Third*
Season	Winter	Spring	Summer
Sea speed (knots)	10.29	10.23	10.16
R. P. M.	86.6	85.2	84.1
I. H. P., main engine	2,270	2,252	2,192
I. H. P., auxiliary engine at sea	100	100	100
Total I. H. P. at sea	2,370	2,352	2,292
Fuel per day at sea (tons), main and auxiliary engine	7.57	7.40	7.28
Ditto, including donkey boiler	7.72	7.50	7.32
Fuel per I. H. P. (lbs.) at sea, main and auxiliary engine	0.298	0.294	0.296
Ditto, all purposes	0.304	0.298	0.298
Fuel consumed per day (tons) in port and running in rivers, harbors, etc.	1.18	1.29	1.19
Miles per ton fuel at sea	32.0	32.8	33.3
Draft	17′ 6″	21′ 6″	19′ 9″

The usual amount of stormy days was encountered, especially on the first voyage. The average speed of the third voyage is less, due to reduced speed between New York and Panama to suit schedule of arrival at the canal.

The consumption in port varies from 0.3 to 1 ton, depending on whether the winches and donkey boiler are in operation, with a mean of about 0.7 during winter and 0.5 during summer months.

Comparison with Steamers.—The only record obtainable of the *Seekonk* operating as a steamer is the log of her last voyage, but which is not given, due to the very poor operating conditions that prevailed. The average results of 70 other sister ships, however, may be taken as a guide, and which are as follows: Draft, 21 feet 8 inches; observed speed, 10.53; tons of fuel per day, 29.14; miles per ton, 8.51.

The port consumption of the steamers may be taken as 8 tons per day, which is the average of the S. S. *Hog Island* for three voyages.

The average time per voyage spent in running in rivers, harbors, and canal is about four days, with the fuel consumption per day about 80 percent that when at sea. The consumption of the steamer correspondingly would be about 22 tons. This makes 9 tons per day for the steamer for port use and slow running, as compared with 1.22 tons, which is the average of the *Seekonk's* three voyages.

For an average sea speed of 10.25 knots the consumption of the motorship can be taken as 7.5 tons and the steamer sister ship as 28 tons. With 53 percent of the time at sea and 47 percent of the time in port, etc., the fuel consumption on an annual basis, per diem, is about 19 tons for the steamer and 4.5 tons for the motorship.

DISCUSSION

W. W. SMITH called attention to the particularly fine arrangement of the engine room of the *Seekonk.*

P. E. KRIEBEL asked if the slip friction clutch fitted in the windlass had been found useful.

CAPT. H. C. DINGER asked for the lowest speed at which the *Seekonk's* engines could be run and also inquired as to the use of salt water for cooling.

C. J. JEFFERSON stated that 10 men now made up the engine room crew on the Hog Island steamers.

CARL E. PETERSEN: In the matter of fuel, it is understool Diesel oil was used on the first two voyages and boiler oil resorted to on the third voyage. Perhaps Mr. Shaw could enlighten us on the success which attended the use of the lower grade fuel, this bearing upon the economic comparison. It would also be interesting if Mr. Shaw could give us data on the comparative weights of double and single acting Diesel engines.

PROF. EVERS BURTNER: One striking point in this very interesting paper is the indication that a 2,300 Diesel indicated horsepower (1,800 shaft horsepower) installation would give as high sea speed as a 2,500 shaft horsepower turbine outfit. It is common knowledge that most steam cargo steamers develop only 70 percent of their full power at sea. Undoubtedly, new turbine blading, boiler tubes, etc., would improve the efficiency of the steamers considerably. It would be interesting to learn the effect of length of service on fuel consumption of the Diesel. While engineers' logs and fuel reports show the fuel consumed at sea, a three quarter and full power eight hour sea trial such as the navy has run on its auxiliary vessels would prove very interesting, if carried out on the steamer and on the motorship.

HUGO P. FREAR: Mr. Shaw speaks of the raised platforms for the winches to facilitate the better handling and stowage of lumber deck cargoes. It is believed that this type of platform with reference to lumber deck loads was first installed on the *Pacific* built at the Union Plant of the Bethlehem Shipbuilding Corporation, Ltd. This vessel, together with a number of others, was, eventually, sold to the Norwegians who thought so much of the idea that they fitted similar platforms on a number of vessels built on the other side, primarily intended for general cargo purposes. The *Pacific* type of platforms were open and lumber could be stowed under them as well as at the sides. In the case of using electric winches, the space under the platforms serves a very good purpose in housing the resistors and controllers which are a troublesome thing to take care of when the winches are fitted close to the deck.

Mr. Shaw states that there is a saving of six men in the engine room crew after conversion as compared with the *Seekonk* with the original steam machinery. From such a great saving it would be concluded that the *Seekonk,* under steam drive, carried an unnecessarily large engine room crew. Mr. Shaw mentions the twin screw *Californian* and *Missourian* in which they installed similar engines. We are glad that these two boats happen to be mentioned, as we understood the owners, the American-Hawaiian Steamship Company, were somewhat disappointed in not being able to reduce the crew on these vessels as compared with their twin screw steamers *Texan* and *Virginian* of approximately the same power. The engine room crew for each of these four vessels is said to be fifteen, the same as stated in the paper for the *Seekonk* under steam drive. If this is correct, it would appear that the twin screw cargo steamers *Texan* and *Virginian,* with about 4,000 indicated horsepower each, only carried about the same crew as the single screw, steam driven *Seekonk* with about one-half the power. The old *Cubore,* with steam drive, had an engine room crew of twelve; the new *Cubore* with single screw, Diesel drive, also has an engine room crew of twelve.

In the early days it was customary to compare engine room crews of Diesel driven vessels with those of coal driven, steam vessels. Under these conditions there was a material saving in crew. A great many people got this idea so firmly in mind that it is often difficult to realize that a proportionate saving cannot always be effected in converting oil burners.

J. C. Shaw stated that no deposits had resulted from the use of salt water for cooling and that the lowest speed at which the engines were run was around 30 revolutions per minute. This had been found entirely satisfactory in maneuvering the vessel.

A Diesel Electric Tug Boat

By Frank L. DuBosque

This paper is published on page 703 of this issue.

Discussion

Admiral D. W. Taylor praised the paper as being a model from every point of view—a particularly timely scientific investigation of operation under actual service conditions.

J. L. Bogart said that the power of a direct connected Diesel towboat could be increased, for short periods, by supercharging.

Albert S. Walker: There is no doubt that the Diesel electric drive is more suitable for the "Float" type of tug than the direct drive. No other drive can be controlled so quickly and surely in the delicate and exceedingly frequent maneuvers required by this work. The fact should not be lost sight of, however, that over half of all the tugs in all harbors spend a good share of their time in work that does not require anywhere near as frequent maneuvering as these "Float" tugs are called upon to do.

The showing made by *Jumbo* against the tug *P. R. R. No.* 10 upholds the opinion held by a great many of us who have been advocating direct Diesel drive, that the smaller high speed propeller compared to the larger, slower propeller with higher pitch ratio does not show to such a great disadvantage in practice as calculations would lead us to expect. Taking into account the slightly greater length, less beam and displacement, and the steel plating of *P. R. R. No.* 10, the respective speeds running free show up well for *Jumbo.* Judging by the revolutions and horsepower running free and towing, it seems that a solid wheel of somewhat larger blade area and slightly greater pitch than the present built-up wheel could be swung handily by *Jumbo* provided the governor were arranged to allow some slowing down of the revolutions when towing. This should give a better towing performance without overheating the engine.

On the whole, this very complete and informative series of tests shows that for general tow boat work, which has much less severe maneuvering requirements than railroad tug work or the "Drill" and "Float" classes, the extra first cost and extra fuel cost of the Diesel electric installation over the direct Diesel drive are rarely justified. For sea going work, the additional complications of the electrical apparatus, slight as they are, decidedly are not an advantage in so small a ship.

E. Nibbs:* I have a correction to offer. It will be noted that the mechanical efficiency of the *Jumbo's* engine is given as 78 percent, as ascertained from the shop tests. While this was correct under the conditions then existing, it should be noted, however, that 73.5 percent is the efficiency of this engine as installed in the *Jumbo,* owing to the fact that a generator supplying power for lights and steering gear as well as pumps for circulating water, lubricating oil, fuel oil and the bilge or fire purposes are also driven from the main shafting. This was not the case when this engine was erected on the test bed.

It is regretted that the correction was not furnished Mr. DuBosque in time for him to incorporate it in his paper, as some other corrections necessarily follow. The shaft horsepowers given in the tables should be 472 and 605 respectively instead of 502 and 642. Part of the last paragraph on page 6 should now read "the maximum speed of 12.28 miles obtained by the *Jumbo* running free could be obtained by the *P. R. R. No.* 16 with 46 (instead of 76 as stated) less horsepower on the propeller shaft, and the maximum tow line stress obtained by the *Jumbo,* 13,160 pounds, could be obtained by *P. R. R. No.* 16 with 90 (instead of 134) less horsepower. The percentage figures then become 10.7 and 17.4 respectively (instead of 15 and 26). Without doubt this is chiefly due to the larger diameter and slower turning propeller of *P. R. R. No.* 16.

The figure of 32 percent on page 7 referring to tow line pull and shaft horsepower should be 35 percent.

It is, I think, only proper to record, that when the propeller for the *Jumbo* was designed, a limiting draft of ten feet was set in order to enable the vessel to undertake towing duties up the Hudson as far as Albany, where the water in which she would have to operate is at times only a trifle over this depth, and therefore the problem was to ascertain the best propeller having been given the draft of the vessel and the position of the stern tube.

It is, of course, recognized that special cases call for special treatments, and no one realizes this more clearly than the company with which I am associated. For any Diesel engined tug proposition, the requirements must be examined thoroughly and their relative importance determined, before any recommendation as to the best installation can be made, but it is instructive to note some of the disadvantages which are incurred as the result, in this case, of the choice falling on the Diesel electric drive.

For example, for the same tow line pull of 13,160 pounds, the *P. R. R. No.* 16 has to produce from her tanks sufficient fuel oil to develop approximately 1,060 indicated horsepower with a corresponding shaft horsepower of about 515. The *Jumbo* has to produce from her tanks sufficient fuel oil to develop 823 indicated horsepower with a corresponding shaft horsepower of 605, in order to obtain the same tow line pull.

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* New London Ship and Engine Company, Groton, Conn.

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This means that the *P. R. R. No.* 16 has to produce 28.5 percent more initial power for the same effect on the tow as produced by the *Jumbo.*

We have already noted that due to the more efficient propeller, the *P. R. R. No.* 16 converts 41 percent and the *Jumbo* 35 percent of the shaft horsepower into tow rope horsepower, but this is only part of the story. Of course, it truly reflects the benefit of the slower turning and hence more efficient wheel, but the *Jumbo* converts 25.4 percent of its indicated horsepower into tow rope horsepower, while the *P. R. R. No.* 16 converts 19.7 percent and these figures represent the overall efficiency. Hence the *Jumbo* can earn a higher return on the same investment, or an even greater return on her lower first cost compared with the initial outlay on the *P. R. R. No.* 16. In the paper it was stated that on the straight Diesel tug, the main engine furnished power for its engine auxiliaries only, but this is not quite correct, as all power requirements on board the boat are taken in practice from the main engine, including lights, steering engine and air for maneuvering, so that the Diesel electric and the straight Diesel tugs are comparable in this respect.

From a consideration of the facts in the paper, and the few remarks I have made, it is very certain that not only should the first cost, fixed charges, overall efficiency from fuel tanks to towline and operating expenses be taken into account, but also the very important item—"nature of work to be performed"—when deciding on the type of Diesel engine propelling unit to be installed in any tug.

Maxwell W. Day*: Mr. DuBosque's paper clearly brings out certain advantages of electric drive for "Float" tugs due primarily to their superior maneuvering characteristics through the employment of pilot house control.

The General Electric Company recently assisted Mr. L. Goldsmith of the Atlantic Refining Company to conduct some rather interesting tests on two of their Diesel electric tugs, the *Van Dyke 1* and *2*. Some comparative tests were made at the same time with two Diesel direct tugs.

The principal dimensions, etc., of the tugs tested are as follows:

Name	*Van Dyke* 1	*Arthur N. Herron*	*Hustler*
Owner	Atlantic Refining Co.	American Dredging Co.	Diamond P. Trans. Co.
Builder	Staten Island Shipbuilding Co.	New York Shipbuilding Co.	Clinton Shipbuilding & Repair Co.
Length overall	97′	99′ 11″	82′ 6″
Beam	21′	23′	19.9′
Depth molded	11′ 6″	12′ 0″	6.9′
Displacement	•	312 tons	159.6 tons
Engines	Two 3-cylinder 225 B. H. P. at 257 r. p. m. Ingersoll-Rand "P. R." Diesel	One 8-cylinder 500 B. H. P. at 250 r. p. m. Winton Engine Wks. Diesel	One 6-cylinder 320 B. H. P. at 250 r. p. m. Ingersoll Rand "P. R." Diesel
Propelling motor	375 S. H. P.		
R. P. M.	107 to 140		

The *Van Dyke 1* was tested under four operating conditions, and the *Arthur N. Herron* and *Hustler* under two operating conditions. The four operating conditions of the Diesel electric tug were:

1. Speed tests without tow.
2. Speed tests with tow.
3. Tow rope pull at dock ahead.
4. Tow rope pull at dock astern.

The two operating conditions of the Diesel direct tugs were:

(A) Speed test with tow.
(B) Tow rope pull at dock ahead.

1. The speed tests without tow consisted of running at several different speeds, recording the motor input, propeller revolutions and speed measuring device revolutions. Knowing the electrical losses from factory tests, the shaft horsepower was calculated.

2. The speed tests with tow consisted of running at several different speeds, recording the motor input, propeller revolutions, speed measuring device revolutions, and the tow rope pull. The tow rope pull was measured by means of a spring dynamometer, which was made fast to the tug.

3. The tow rope pull at dock ahead consisted of taking several different pulls, recording the motor input, propeller revolutions and tow rope pull. The dynamometer was made fast to the dock, the tow rope being made fast to the tug.

4. The tow rope pull at dock astern was the same as ahead except making the tow rope fast to the tug's bow and backing.

(A) The Diesel direct speed test with tow consisted of towing the same barge, using the same tow lines and dynamometer that had been used in the Diesel electric tug tests, and recording the engine revolutions. The speed was obtained by pacing the towing tug and recording the speed measuring device revolutions for ten minutes.

(B) The Diesel direct tow rope pull at dock ahead was made using the same dynamometer made fast to the same dock and using approximately the same length line.

A comparative running light test was made between the *Van Dyke 1* and the *Arthur N. Herron.* The speed of the respective tugs was not observed, but after running for some little time the *Van Dyke 1* was several boat lengths ahead of the *Arthur N. Herron,* showing very clearly that the *Van Dyke 1* was the faster tug.

The *Van Dyke 1* was capable of towing the test barge at the same speed as the *Arthur N. Herron* when delivering 62.5 percent of the rated horsepower of the *Herron* to the propeller shaft, and required 69 percent of the shaft horsepower to exert a tow rope pull at the dock equal to that of the Diesel direct tug.

Hugo P. Frear: For regular tug boat work, it is customtomary to design screws more especially for towing than for speed. When heavy oil engines first began to figure in marine work, it was the custom to fit twin screws on account of the prevailing high revolutions per minute and unproven reliability, but now owners are demanding single screws and long stroke, slow turning engines The slow turning screw is all the more important in a tug on account of the low speed of advance and small, inefficient, pitch ratios necessary to insure full power when towing. It is not surprising that the Diesel electric driven tug with its slow turning propeller demonstrated its superiority over the straight Diesel driven tug *Jumbo* on every test. At the slow speed of towing, differences in handling would not be influenced by the character of the models to the same extent as when running free.

Considering propeller speeds, there does not appear to be enough difference in the speeds between the *Jumbo* and *P. R. R. No. 16* on the powers given, unless the *Jumbo* is credited with a better model for speed. Plotting the speeds and estimated shaft horsepowers in conjunction with the speed and power curve of another tug of slightly less displacement length ratio, and joining the two spots does not appear to indicate as great a difference in the slopes of the two lines as might be looked for.

It is noted that the engines in the *P. R. R. No. 16* are well forward, and it may be that some sacrifice in the entrance may have been necessary on this account. This might have more than offset some possible disadvantages to the smaller propeller of the *Jumbo* and the thickness of deadwood and rudder or rudder post.

Capt. Elliot Snow, C. C., U. S. N.: If Mr. DuBosque can supply additional information concerning the auxiliary power performance of this installation, it will add considerably to the interest and value of the paper. The measurements of the power furnished for auxiliaries, from the main generators and through the exciters, is a very easy matter with an electric installation such as this. The summation of the power delivered by the main generators for

(*Continued on page* 748)

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* General Electric Company, Schenectady, N. Y.

Practical Diesel Engineering—VI

Derangements Likely to Occur in Operation and Adjustments Required for Their Correction

By Louis R. Ford*

UPON first sight the Diesel engine is apt to create the impression that it is a very complicated mechanism but a little analysis will reveal that it is actually more simple than the steam plant. In comparing the two it should be borne in mind that the steam engine alone is not a usable machine; to be able to use it we must have a boiler and all the attendant mechanism, including pumps, piping, water tanks, condenser, etc., and the complete steam plant becomes quite a complicated thing. The Diesel engine, on the other hand, may be arranged so that all of the apparatus required in its operation as a power plant may be attached directly to the engine itself.

Fundamentally all Diesel engines are alike, since the processes that occur in their operation are the same in all of them, and the only way the various builders can depart from standard construction is in the design of the various accessories used in operation. In every Diesel engine built there are four functions that must be performed and the only latitude the designer has in trying to design an engine different from the others is in varying the details of the mechanism for executing these functions. These four functions are: Charging the cylinders with air; control of fuel injection and control of combustion after the fuel is injected; cooling of the parts exposed to the heat of combustion; transformation of the power obtained from the fuel into work by means of mechanical parts.

Perhaps the most striking difference in the problem of maintenance of the Diesel engine as compared to steam engine maintenance arises from the fact that the steam engine can be allowed to fall, more or less gradually, into a very bad state of disrepair and it will continue to run but the Diesel engine must be pretty nearly right or it will not run at all. The steam engine that is not kept in good repair indicates its condition by a falling off in power and increased consumption of fuel. If the maintenance requirements of the Diesel engine are neglected, the usual result is that it will stop and sometimes this stoppage will come with so little warning as to result in the ship being caught in a very dangerous situation.

DERANGEMENTS AND ADJUSTMENTS

The derangements likely to occur in operation and the adjustments required to correct them may be grouped into the following general classes:

(a) Wrong fits and clearances, looseness and tightness of parts.
(b) Mechanical defects.
(c) Fuel system.
(d) Combustion.
(e) Cooling water system.
(f) Lubricating system.
(g) Air system.
(h) Starting difficulties.
(i) Operating troubles in general.

Derangements falling into these several classes may be discussed in a general way insofar as the possibility of their occurence is common to all types of Diesel engines. This discussion will be followed by consideration of the details of procedure in correcting them as affected by variations in type and arrangement of parts, which is something Diesel engineers should know.

WRONG FITS AND CLEARANCES

The principal source of trouble from this cause is the large bearings of the main shaft, cranks and crossheads. In general the unit bearing pressures are higher in the Diesel than in the steam engine and more careful and accurate fitting is required, so that the maximum bearing surface will be obtained. All bearings must be relieved at the sides enough to prevent gripping and to assist the spread of the lubricating oil around the bearings but not enough to reduce the bearing surface too much when they expand with the heat. All of the bearings, large and small, about the engine are subject to wear and looseness may develop in any of them in service but the large bearings just mentioned have the most severe duty to perform and require adjustment more often than the others.

The rate at which the various bearings will wear down depends on how good the bearing metal is and how near perfect the lubrication is, assuming that the service load does not exceed that for which the bearings were designed. As a general rule the bearings on a new engine are carefully adjusted for correct running before leaving the builder's shops but even unusually severe shop tests do not involve operation long enough to run the bearings in to a final fit. The most accurate scraping and fitting of new bearings does not produce the smooth, even bearing surface that is obtained from a period of operation in service. For this reason the large bearings of a new engine should be gone over after about 800 to 900 hours of running, to take up any excess clearance that may have resulted from the wearing in period. After this initial wearing in much less frequent adjustment should be required if the lubrication is right.

Incorrect fit of pistons in the cylinders and piston rings in their grooves sometimes causes trouble. Too little clearance, resulting in sticking, is due to incorrect fits allowed by the builder or errors in machining that sometimes escape detection by the inspectors. This trouble may not appear in normal running but may occur during periods of overload, when the working temperatures rise. Most engine builders make every endeavor to establish correct standards for all fits and clearances but it has always been, and will continue to be, a fact that it is impossible in design and manufacture to provide against all the possible service operating conditions. Neither is it possible to duplicate operating conditions in test stand work. Too much clearance of pistons and rings may be due to errors in design or manufacture, if present in a new engine, but, if it develops after a period of running, it is due to wear of liners and rings. Excess clearance at these points brings on a number of troubles, such as loss of compression, smoky exhaust, increase in fuel consumption and fouling of cylinders, pistons and rings.

The fit of long, guided valve stems, such as in spray valves, involves some careful work in designing and machining and failure to get clearances exactly right will result in trouble for the operating engineer. It is interesting to note, in the specific case of spray valve stems, as shown in Fig. 21, that sticking or seizing while running may be due to either too little or too much clearance between stem *A* and guide *B*. The mushroom, or inward opening, type valve habitually operates at a rather high temperature, due to the head or disk of the valve *C* being exposed to the hot gases in the cylinder. If the clearance is too little, the expansion of the stem will cause it to stick in the guide. On the other hand, if the clearance is too great, fuel oil from the lower part of the valve body will work up into the space between the stem and guide, carbonize or gum under the action of the heat from the stem and eventually cause sticking. It may sometimes happen that the engineer, thinking that a valve stem that is stuck from this latter cause is too tight, will grind the stem to give it more clearance and the trouble will be aggravated instead of cured. A pretty good guide in this matter is to watch for carbonized oil on the stem. Its presence will indicate the possibility of too much clearance but a binding stem that has no carbon discolorations is apt to have too little.

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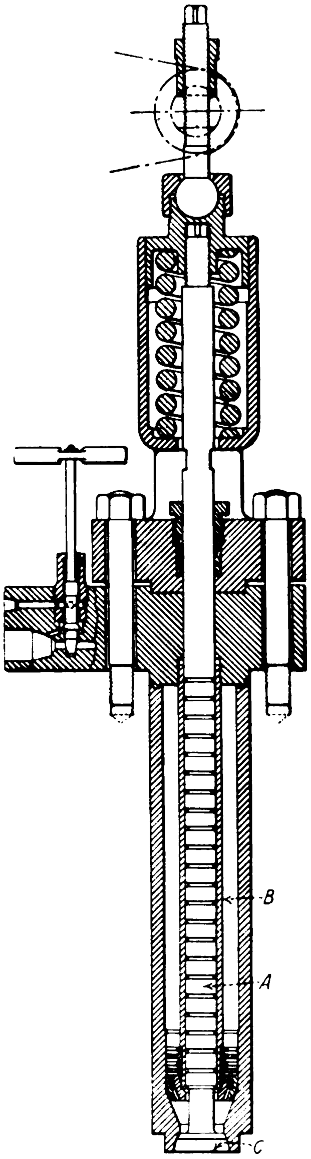

Fig. 21.—Spray Valve with Long Guided Stem

Clearances between valve rollers and their cams, if not correct, will result in trouble. Too little clearance will prevent the valves closing and cause loss of power and general bad running. Too much clearance will cause a roller to meet the high part of its cam later and leave earlier, thus affecting the times of opening and closing and the duration of opening. It will also cause noisy operation of valve gear. The effect of excessive cam clearance may be seen in Fig. 22. The path of the bearing face of the roller when the clearance is normal is shown by the broken line. The roller makes contact with the cam at the point *A* and leaves it at *B*. The total duration of valve opening, neglecting lost motion in the valve gear, will be the time required for the cam to turn through the distance represented by the arc *A E B* and the total lift of the valve will be represented by the distance *E F*. If the clearance is increased so that the roller describes the path shown by the dotted line, contact will be made at *C*, the roller will leave the cam at *D*, the duration of opening will be *C G D* and the total lift will be *G F*.

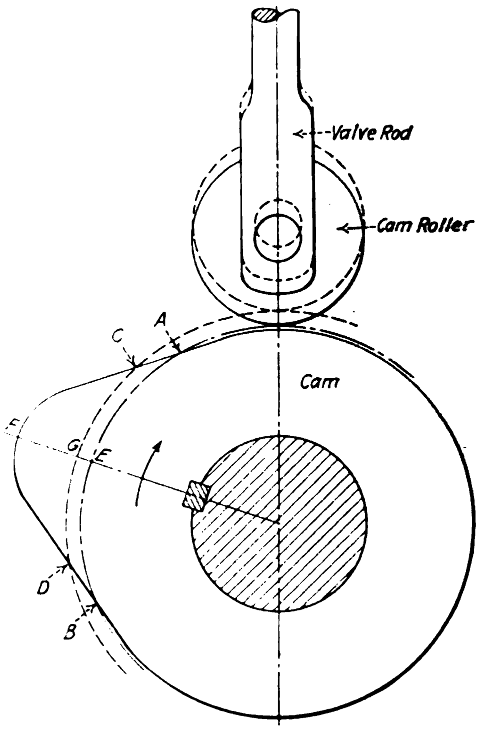

Fig. 22.—Effect of Increasing Cam Roller Clearance

Mechanical Defects

Mechanical defects resulting in failure of parts in service may be errors in design, errors in machining or defects in the material itself. Errors in design have been too numerous to catalog but in the case of most well established builders such errors have been eliminated by experience in operation. Errors in machining are rarely found in an engine, if the manufacturer has an efficient inspection department. A typical design error that resulted in some expensive breakages before it was corrected is shown in Fig. 23, which shows a section through a portion of the bottom end of a cylinder of

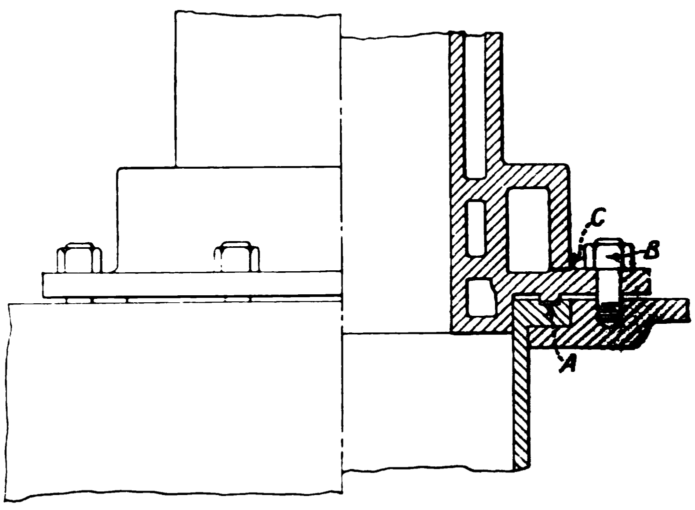

Fig. 23.—Cylinder Breakage Due to Faulty Design

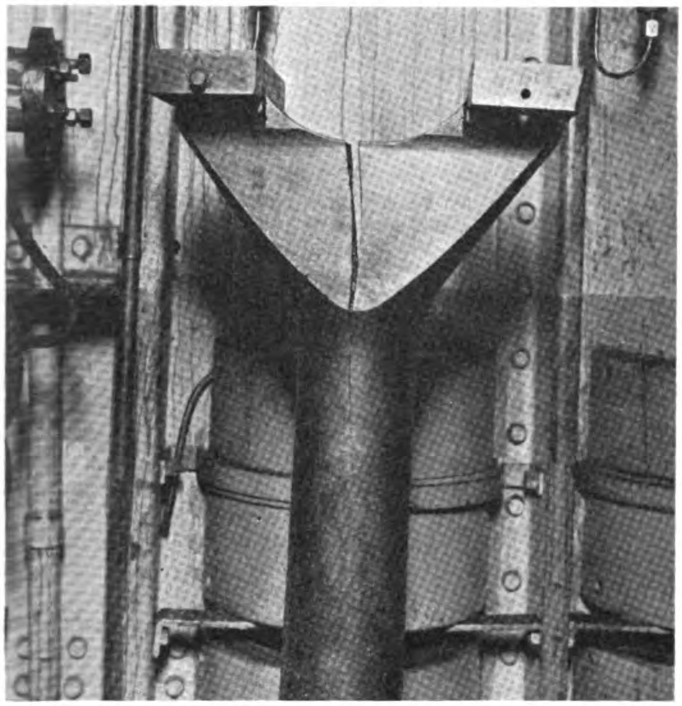

Fig. 24.—Broken Connecting Rod Due to Defective Forging

a step piston type of engine where it is jointed to the housing with a male and female joint. The joint at *A* prevents contact between the flange faces and when the holding down nuts *B* are sledged down tight a powerful bending moment is produced in the cylinder flange. An inadequate fillet at the point *C* resulted in cracks at this point.

Defects or flaws in materials are often impossible to detect before breakage occurs. An example of this is seen in Fig. 24 which shows a Diesel engine connecting rod which failed in service. Outwardly this forging was perfect but after it broke it was found to be piped at the point of fracture.

Sometimes careful investigation and analysis will reveal that a breakage that was apparently caused by a mechanical defect was due to bad work or neglect on the part of the engineers. An example of this is shown in Fig. 25 which shows a broken Diesel engine crankshaft. The first conclusion was that this was caused by either defective metal in the shaft or incorrect balancing of the engine. Investigation later developed the fact that the shaft bearings had been allowed to wear down until the shaft was badly out of line, one bearing box being so low that the bottom half never touched the shaft.

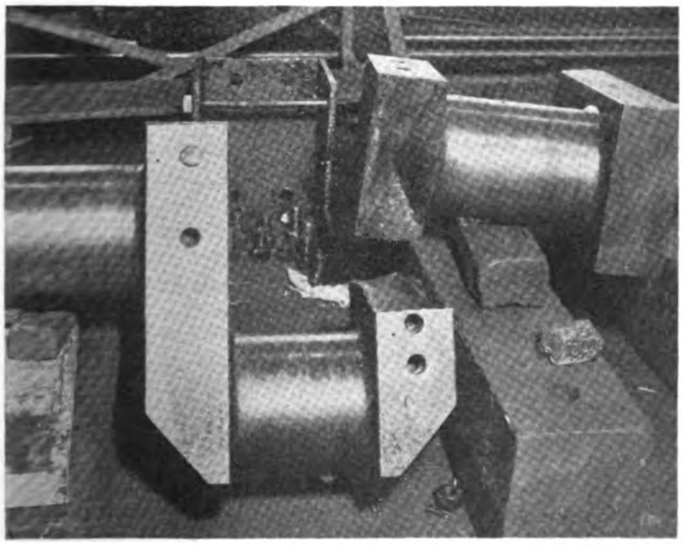

Fig. 25.—Break in Crankshaft Caused by Badly Worn Bearings

FUEL SYSTEM

Derangements in the fuel system are most likely to occur at the fuel measuring pumps. These pumps must handle a very small amount of oil at high pressure on each stroke and in order to do this the suction and discharge valves must be kept in perfect condition. A frequent source of trouble with these valves is dirt or grit in the oil. A small particle of sand or a thread of waste under a valve will cause it to leak. Good strainers should be provided in the fuel oil supply line to the pumps and the strainers should be cleaned frequently. The pump plungers should be very carefully packed to prevent leakage of oil outward and air inward. Accumulation of air in the pumps will cause either irregular supply of fuel to the engine or stoppage. Stoppage of fuel supply to any one cylinder throws extra load on the other cylinders when the governor acts to increase the pump discharge. Repeated regrinding of the pump suction valves will require careful checking of the pump timing.

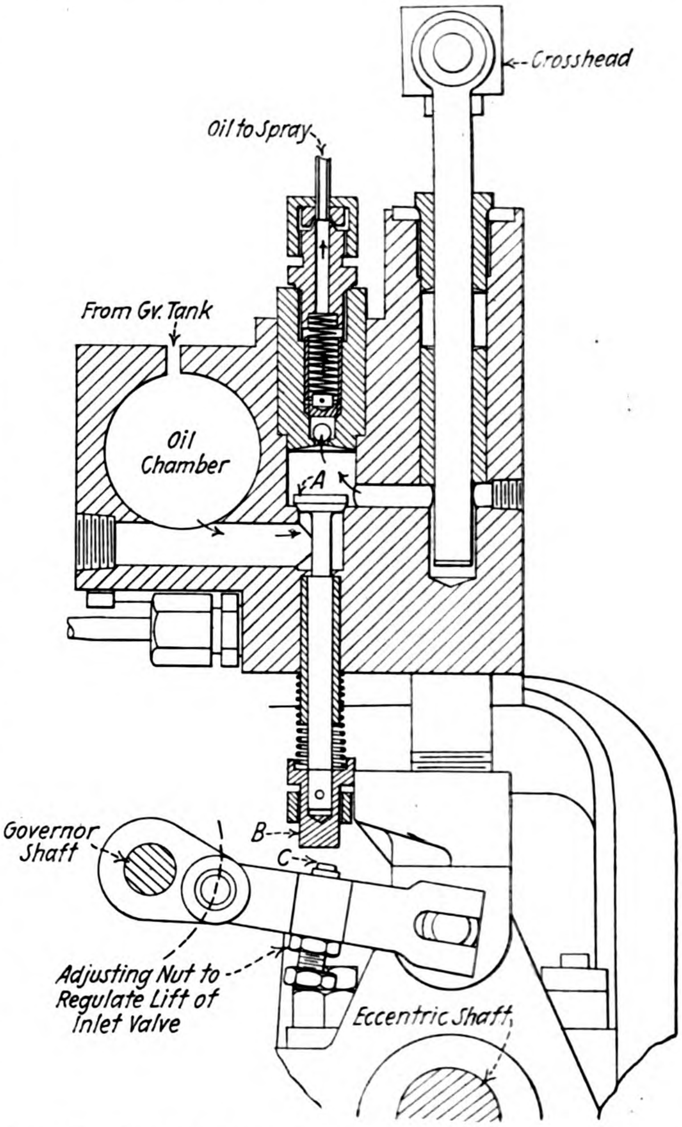

Fig. 26.—Section Through Fuel Pump. Clearance Between B and C Decreases When Suction Valve Is Ground In

Reference to Fig. 26, which is a section through a fuel measuring pump assembly, will show that each time the suction valve *A* is ground into its seat it is brought down a little lower and decreases the clearance between the end of the stem *B*, and the valve lifting tappet *C*, thus causing the valve to be lifted earlier and the supply of fuel to the cylinder to be decreased. The pump valve operating gear usually includes a number of fulcrum pins and bushings that must be watched for wear. Unless the slack due to this is correctly allowed for when setting the valves the timing will not be right.

Combustion

Normally the combustion in each power cylinder should be smokeless and complete and occur early in the stroke. Insufficient breaking up of the oil during injection will cause slow and incomplete burning and may be the result of clogged atomizer disks, oil too cold or air pressure too low. Other causes of incomplete burning are compression too low, spray valves not correctly timed and air inlet pipes clogged.

When burning of the fuel is too slow it may or may not be accompanied by smoke in the exhaust. The burning may be so slow that it is not completed until the end of the stroke and it may even continue in the exhaust manifold with no smoke showing. The indicator card will show late burning but without a card this condition will be indicated if there is an abnormal rise in the temperature of cooling water without any decrease in the water supply. A leaky spray valve will cause smoke by letting oil dribble into the cylinder before time for injection. A leaky exhaust or inlet valve may also cause smoke by reducing compression. When smoke appears in the exhaust from a multi-cylinder engine it is not always easy to determine which cylinder is producing it unless there is some obvious defect in the valve mechanism that will locate the trouble. The try cock in the exhaust passage from each cylinder is not to be depended on as a smoke indicator. Excessive lubricating oil in the cylinder will produce smoke in the exhaust but it is usually lighter in color than that produced by fuel oil.

Cooling Water System

Complete stoppage of the cooling water supply can hardly occur unless the circulating pump breaks down or the ship grounds in shoal water where mud may plug up the sea injection valve. In the event of the rare occurrence of pump breakage there is always an auxiliary pump available. Most well designed ships, especially when designed to operate in shoal water, have high and low sea suctions. The high suction is used in shallow water where mud might be drawn in through the low suction. The low suction should always be used at sea as the rolling of the ship is likely to throw the high suction out of the water and admit air into the system. It not infrequently happens when ships anchor in tropical harbors that the sea suction becomes clogged with jelly fish. When this happens it can be cleared by blowing out, if a steam or air connection on the body of the sea valve is available.

Failure of the water supply to any individual cylinder or piston may be caused by an air pocket in the supply line to that point or in the upper part of the cylinder head. Where all of the cooling water is passed through the coolers on the spray air compressor before reaching the engine jackets a leak in a cooler will allow high pressure air to blow into the water and stop the supply to all cylinders.

The thermometers on the various branches of the system should be watched for any sudden rise in temperature and all vent cocks should be opened at regular intervals to let out the air. Many engines are equipped with visual overflow pipes leading from the tops of the cylinders to some point near the operating station to give the engineer a constant check on the flow of water. If the ship operates in muddy water there may be a gradual accumulation of mud in the bottoms of the cylinder jackets that will have to be washed out occasionally. If the cooling water is shut off too soon after stopping the engine, the water left in the jackets may get hot enough, by absorption of the heat stored in the metal, to settle out scale. In this way there will be a gradual accumulation of scale that will eventually result in cracked cylinders or heads.

Leakage of cooling water into the crank pits or any other point where it may mingle with the lubricating oil will result in trouble with the bearings. The oil and water will form an emulsion that will clog the forced feed lubricating system.

(*To be continued.*)

Extent of Cavitation in U. S. Scouts and Destroyers*

Introduction of Air to Propeller Disk, Through Eddies Forming Behind Struts, Believed to Be Responsible for Divergences Between Model and Trial Results Rather Than Cavitation

By Captain E. F. Eggert, C. C., U. S. N.

It has been the opinion among naval architects that when propellers reach a certain degree of overloading, a phenomenon known as cavitation begins to make itself felt and becomes more important as the overload increases. This cavitation has been described by some writers as the formation of cavities on the backs of the blades; by other writers as cavities on the face, or face and back; and other descriptions have been given.

Under certain exaggerated conditions, this cavitation has been experimentally produced and been made visible to the eye, its chief characteristics then depending on the particular exaggeration of the conditions.

Various authorities have assigned a tentative limit for normal design of propellers at which cavitation might be expected to begin, this limit, in the case of one well-known authority, being given as 10,000 feet per minute tip speed.

With this assumption, it was fully expected that the propellers for the destroyers built during and since the war, and also those for scout cruisers 4 to 13, would show decided effects of cavitation; these effects are defined as a progressive divergence between trial powers and revolutions at given speeds, and the corresponding powers and revolutions deduced from model experiments.

These divergences in the cases of the destroyers at higher speeds were quite large and were extensively discussed in Model Basin reports in 1921 and earlier.

Divergences Disappear in Scouts at Deeper Drafts

The later destroyers having a tip speed of about 12,000 feet per minute and the scout cruisers a tip speed of over 13,000 feet per minute, it was expected that the standardization trials of the latter would indicate equally great diver-

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*Paper read before the Society of Naval Architects and Marine Engineers, New York, November, 1924.

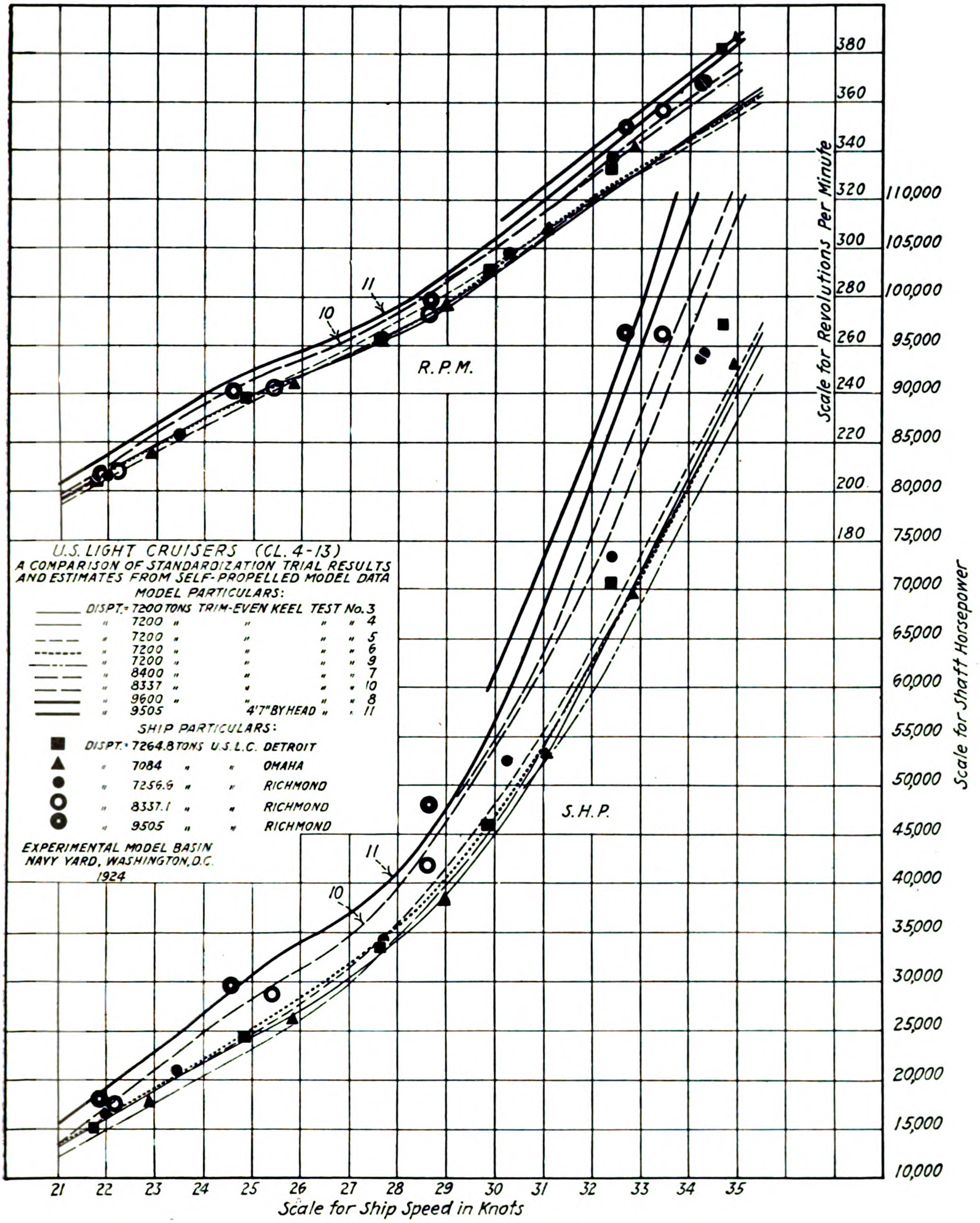

Fig. 1.—Comparison of Standardization Trial Results and Estimates from Self-Propelled Model Data

gences; and it was surprising to find, when three of these vessels were standardized, at their contract displacement of 7,200 tons, that the divergences were relatively small; in fact, in the case of the *Omaha*, so small as to be nearly nonexistent. Still more surprising, however, was it to find that when standardizing at deeper drafts, corresponding to about 8,300 tons and 9,500 tons displacement they showed less divergence from the Model Basin results, and in the case of

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the deepest draft almost none. These latter trials were of the *Richmond,* which on light draft had shown the greatest divergence.

These results were so remarkable that the Model Basin experiments were repeated a number of times. In all, five separate series of runs were made with the model self-propelled at light draft, and two sets each at the deeper drafts. All of these results are plotted on Fig. 1. The curves shown are the results of the Model Basin experiments and indicate, by their scattering, the degree of precision that may be expected from such work. The spots plotted are the trial spots as reported by the Trial Board.

It is evident that cavitation, as it is usually described, cannot be the cause of the differences shown in the case of these cruisers, for had there been cavitation, which means a departure of the streams of water from the surfaces of the propeller blades, such cavitation would have become worse at a given speed as the displacement increased, because the thrust of the propellers would increase and therewith the slip and slip angle. On the contrary, the divergence became less as the displacement increased until, at the deepest displacement, it had almost disappeared. There is a further peculiarity in these results, in that the *Omaha,* at light draft, showed less divergence than the other two cruisers; in fact, almost none. Investigation showed that there was a significant new condition of the trial in the case of the *Omaha* in that she was run trimmed considerably by the stern. In other words, the propellers had more submergence than those of the other two cruisers. It is, of course, evident that this submergence of the propeller increases also as the displacement of the ship is increased.

Eddies Behind Struts Direct Air to Propeller Disk

It is plain that cavitation does not fit as an explanation of the results of these trials, and another explanation must be sought. Cavitation depends only on the relative speed and direction of the stream past the propeller surfaces and is not changed appreciably by change in submergence. In this case, however, it seems that submergence was the controlling factor and not the degree of loading of the propellers. The only factor that can thus influence the performance of the propeller as its submergence is changed is the introduction of air into the propeller disk. It was noted in the early days of the design of the scout cruisers that air could be, at times, drawn down along the rear edge of the propeller struts, in the model. At the light contract draft, the upper strut palms are very near the surface when the vessel is on an even keel, and when account is taken of the stern wave and the change of trim at full speed. Considerable eddying must be set up by this strut palm and the strut below it, especially in slightly disturbed water, and there would at once be opened an air tube, which, at increasing speed, would extend farther and farther down until air was introduced into the disk. This was experimentally shown on a model in the Basin, as will be described below. The eddy increased in depth as the speed increased, and the great increase in divergence, as shown in this test, was therefore to be expected with the increase of speed. Again, if the vessel at light draft is down by the stern, this divergence would be later in appearing, and the same thing applies if the vessel is given increased draft throughout. In other words, although the actual happening in this case was directly contrary to what might be expected from cavitation, it agrees in all respects with what may be expected from the introduction of air to the propeller disk, through eddies forming behind the strut, and it is becoming the opinion of the Model Basin that cavitation in the case of the scout cruisers is absent.

This conclusion led to reconsideration of the case of the destroyers, on which case report was submitted in June, 1921. It is evident at first glance that the divergences between trial results and basin results, above what has been considered the cavitating limit, are very great. They are also very different for the different destroyers, so different, in fact, that the cavitation theory cannot cover them, and an explanation by means of cavitation therefore seems very doubtful.

In the case of the destroyer, the upper strut arm breaks the surface under all conditions, and eddies form behind the strut, finally allowing air to get down to the propeller disk. It is clear that the amount of eddying or the size of the air tube must be greater than in the case of the scouts, where the strut only approaches the surface. Furthermore, small changes in the shape of the strut section, or how it is set regarding the fore and aft line, might make considerable difference, and a well-formed and smooth strut might give worse results, if it is not alined correctly, than a rough and ill-formed strut, which is placed in the proper streamline. But, generally speaking, a small difference in the bluntness of the after edge of the strut should show a considerable difference in the results.

Destroyer Model Tests Strengthen Theory

To test this idea of the divergence being due to air being directed down abaft the propeller strut, one of the destroyer models was fitted up as before for self-propulsion, but the after edge of the strut was blunted and its thickness increased, more or less, in various experiments, up to a maximum of 5/32 inch. When this model was run self-propelled the phenomena described above, in connection with air being drawn down through the eddy, were easily observed. As soon as a certain definite speed was reached, the eddy behind the strut would form and would go deeper and deeper as the speed was increased until it reached the propeller hub. At this point there seemed to form a continuous sheet of air between the strut and the propeller disk.

Measurements of powers and revolutions, and the corresponding prediction for full size, show, in the case of the thickest strut edge, divergences from previous results, quite similar to those shown in the trials of the vessel. The divergences were, however, considerably greater. In the case of the smaller thicknesses experimented with, these divergences were only small. It appeared that a definite size of air tube was necessary to bring down sufficient air to affect the results considerably.

While these experiments are not conclusive, they indicate that a process of directing air down the strut is not beyond possibility, and that, in case it happens, the results are comparable to what has actually been found on trial. It seems that the matter is well worth further experiments, which must, however, be performed on full size. It might be pointed out that, in the case of the scout cruisers at deep draft, there appears to be nothing to be gained, yet in the case of the destroyers there is a difference of 3 knots, more or less, between the Model Basin predictions and the trial results, for full power, and if this difference is to be entirely ascribed to the effect of air going down the strut, it would seem that prevention of this occurrence would be well worth while. There is, however, also a possibility of air entering the propeller disk directly from the surface, over the tips. This has sometimes occurred in the Model Basin, but only at a very high slip, such as occurs when the carriage is at a standstill. In full size, this might occur more readily at lower slips, especially in rough water, and this possibility should be kept in mind.

Suppression of Upper Strut Arm Proposed in New Designs

To avoid having the air travel down the struts, in the case of the destroyers, it is evident that nothing can be done in the way of fining the strut arms. In new design, it is probable that the best results would be obtained by the suppression of

(*Continued on page 748*)

Questions and Answers Relating to Naval Architecture and Marine Engineering

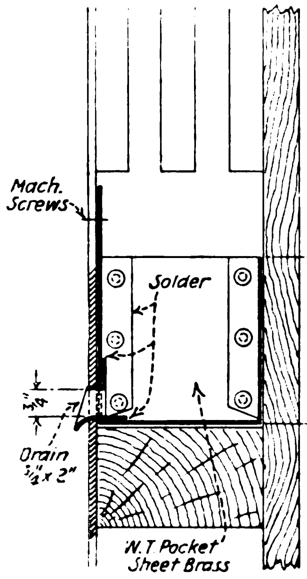
Conducted by James L. Bates, Naval Architect, and W. B. Newton, Marine Engineer

This department is maintained for the purpose of answering all questions relating to ships and their machinery. All inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given permission to do so.

Height of Lining for Sliding Window Sash

Q. (1,282).—**With sliding window sash, how high should the copper lining extend above the bottom of the pocket?**

A. (1,282).—It is assumed that the windows are located in a structure wholly wood or having a metal exterior with wood ceiling and that the distance between the walls of the pockets is about 4 inches.



Section Through Window Pocket

With the usual method of fitting windows, if proper drainage from the pocket is provided, the lining need not extend more than 4 or 5 inches above the bottom of the pocket.

The sketch represents actual construction of such a pocket on a tug.

Cooling Water for Condenser

Q. (1,285).—**Please solve the following question: A 200 horsepower engine uses 18 pounds of steam per horsepower per hour. The condenser carries a vacuum of 24.24 inches of mercury when the barometer reads 28.33 inches of mercury. The condensing water is raised 40 degrees in passing through the condenser. How many pounds of condensing water are required per hour to condense the steam from the engine?—F. V. G.**

A. (1,285).—In solving this problem certain important information has been omitted which will be assumed in order to reach its solution:

Barometer reading, inches $= 28.33$.
Correction constant, inches to pounds $= 0.491$.
P'' = actual atmospheric pressure $= 0.491 \times 28.33 = 13.91$.
R = water rate $= 18$.
H.P. = engine horsepower $= 200$.
W = pounds of steam per hour to be condensed $= 200 \times 18 = 3{,}600$.
B.t.u. in one horsepower hour $= 2{,}545$.
H_u useful B.t.u. per pound steam $= 2{,}545 \div R = 2{,}545 \div 18 = 141.4$.
P' = steam pressure in steam chest, pounds gage $= 186$ (assumed).
P = steam pressure in steam chest, pounds per square inch absolute $= P' + P'' = 186 + 13.91 = 199.91$ (call 200).
Q = quality of steam at pressure $P = 0.99$ (assumed).
H' = heat contents in dry steam at pressure $P = 1198.1$ B.t.u. per pound.
L = latent heat in steam corresponding $P = 843.2$ B.t.u. per pound.
h = heat of liquid above 32 degrees F. corresponding to $P = 354.9$ B.t.u. per pound.
H = total heat in steam corresponding to P and Q, B.t.u. per pound.
$= h + (L \times Q) = 354.9 + (843.2 \times .99) = 1{,}189.6$.
t_w = temperature of hot well, degrees F. $= 90$ degrees (assumed).
h_w = heat of liquid corresponding to t_w per pound $= 58$ B.t.u.
H_t = heat transferred to cooling water B.t.u. per pound of steam per hour.
$= H - (H_u + h_w) = 1{,}189.6 - (141.4 + 58) = 990.2$.
t_r = temperature rise of cooling water $= 40$ degrees F.
C = pounds of cooling water required per pound of steam $= H_t \div t_r$.
$= 990.2 \div 40 = 24.8$.

Gallons of salt cooling water required per minute

$$= \frac{C \times W}{60 \times 8.55} = \frac{24.8 \times 3{,}600}{60 \times 8.55} = 174.$$

It would be well to add to this amount a margin of say 15 percent when decided upon the pump capacity

$$\text{G.P.M.} = 174 \times 1.15 = 200.$$

Marks and Davis Steam Tables have been used in the above calculations.

Economy of Feed Water Heaters

Q. (1,286).—**"A" claims that there is a saving in fuel with closed type feed water heater, maintaining the back pressure between 15 to 20 pounds, as it will heat the feed water to about 230 degrees F. "B" claims that there is no economy in the closed type heaters due to the fact that a back pressure has to be obtained in order to heat the water to that temperature, also giving several other reasons, which are: (a) For every pound of back pressure increased a pound more of live steam has to be used on all machinery running against it in order to maintain the normal speed. (b) Radiation losses in the heater itself and the fittings leading to and from the heater. Majority of heaters are so constructed that the area of the shell surface is equivalent to the total heating surface, therefore the heat energy that is imparted to the shell of the heater is a loss of heat units. The energy that is required to transfer the heat through the metal coils to the water itself is another loss. Coils after a period of usage accumulate a non-conductive dirt on the surfaces. "B" favors the open type heater as being economical, as it requires no back pressure to heat the water. All formulas that we have looked up do not take into consideration the back pressure effect on machinery running against it.**

A. (1,286).—Tests show that with a closed feed water heater using exhaust steam at about 10 pounds gage pressure as the heating agent about 1 percent less coal is required for each 11 degrees rise in feed water temperature. With an increase in exhaust steam to, say, 20 pounds to obtain the same power in the auxiliaries as before, more steam would be required to operate them but, in turn, more exhaust steam and at a higher temperature will be available for feed heating. This increase of feed temperature will, of course, result in a decrease in the amount of fuel required per pound of water evaporated. While it is possible that there might be a slight decrease in economy between the two conditions, yet they will not be far from balancing up. Of course a point could be reached when this increase in back pressure would more than offset any gain by feed heating.

The accepted formula for fuel saving is:

$$\text{Percent of coal saving} = \frac{T_2 - T_1}{T_s - T_1 + L} \times 100$$

In which T_2 and T_1 are the leaving and entering feed water temperature in degrees F., respectively. T_s = temperature of steam at absolute boiler pressure in degrees F. L = latent heat in steam at boiler pressure.

The open type heater with its connections is simpler in construction and quicker in action than with tubes, as in the closed type. It has, however, the disadvantage of requiring an additional pump; one for forcing the water from the hot-well to the feed heater and the other for drawing the water from the heater and discharging into the boiler. In the case of the closed type heated, the flow of water is continuous through the heater to the boiler, its tubes being a part of the feed system and no additional pump is required.

While the open type heater permits the use of somewhat lower heating agent than the other and consequently a slight increase in economy of the auxiliaries, yet this economy may be offset by the extra amount of steam required to operate the additional pump and the decreased heating power of the heating agent.

The open type of heater is not used in naval and marine service in this country.

Naval Architects' Meeting

(*Continued from page* 740)

propulsion, and the power furnished through the excitors, if known, will furnish an excellent check on the recorded indicated horsepower of the prime mover, the amount of which is in doubt. It is somewhat of a surprise to me to note the wide difference between the indicated horsepower of the Diesel engines and the horsepower delivered by the generators. If the efficiency of the prime mover is taken as being equal to that claimed for the *Jumbo* or 78 percent, there is a considerable consumption of power for purposes other than propulsion.

William T. Donnelly: The outstanding feature to which I wish to call attention is the very low percentage of the total power delivered to the tow line in towing, even when proceeding at a speed somewhat more than six miles per hour. My own investigation has shown that the overall efficiency drops off very rapidly as the speed of the tow is reduced. At a general speed of from 2 to 2½ miles per hour, which was found to hold throughout all our Atlantic Coast waterways, the efficiency of towing may be considered to be between 20 and 25 percent. In view of these considerations I would submit the very great desirability and importance of investigating the possibility of transmitting power between vessels afloat by means of electricity over a flexible conductor, for by this means it is entirely practical to obtain an efficiency of power application of between 60 and 65 percent, practically three times that obtained in towing.

The Annual Banquet

Over five hundred members and guests of the Society attended the annual banquet at the Waldorf-Astoria hotel on the evening of November 14. Capt. Walter M. McFarland, president of the Society, acted as toastmaster and among the speakers were the following: James A. Farrell, president of the United States Steel Corporation; Rear Admiral C. J. Plunkett; Brigadier General William Weigel; Professor James T. Shotwell, of Columbia University; Ira W. Campbell, of the law firm of Kirlin, Woolsey, Campbell, Hickox & Keating; Stevenson Taylor, president of the American Bureau of Shipping, and Admiral David W. Taylor.

The Extent of Cavitation

(*Continued from page* 746)

the upper strut arm, increasing the lower one sufficiently to take the weight. It is considered that, in all new designs of any class of ships at high speed, this question should be given careful consideration.

Assuming that the above explanation holds, for these two classes of vessels, a new field of usefulness appears to have been opened for the Model Basin. Under such circumstances, it would appear that the Model Basin predictions for high speed vessels might be considered correct up to the highest speeds, if the strut design has been correct. Furthermore, it appears that any empirical corrections of Model Basin power and revolution predictions would be decidedly uncertain, if they are dependent on the amount of air that is directed down to the propeller disks, and that any method of prediction of propeller performance, which includes an estimate of cavitation, should be well reconsidered.

PERSONAL MENTION

Bradley W. Palmer has been elected to the newly created position of chairman of the executive committee of the United Fruit Company.

William Newsome of Boston has been appointed president of the Fruit Dispatch, the transportation company allied with the United Fruit Company.

William J. Hanna has resigned from the staff of the International Shipping Corporation and will join the nitrate department of W. R. Grace and Company.

I. H. Brown, of the manifest division of Furness, Withy & Company, Ltd., has been appointed assistant to Victor Freeze in the New York office of the Shipping Board.

Alfred H. Bromell has resigned as vice-president and director of the Munson Steamship Line. Mr. Bromell has established temporary headquarters at 63 Wall street, New York.

A. R. McMullin has been appointed sales manager of the Busch-Sulzer Brothers-Diesel Engine Company, St. Louis, Mo., succeeding E. B. Pollister, who is now general manager.

Ernest Lee Jahncke has been appointed president of the Jahncke Drydocks, Inc. He has also been appointed vice president of the Atlantic Coast Shipbuilders' Association.

W. E. Halm, president of the New York Dock Company, was elected vice-president of the New York Board of Trade and Transportation at a recent meeting of the board of directors.

William F. Diehl, formerly assistant manager of the Philadelphia offices of the Dollar Steamship Company, has been made manager at this point to succeed George H. Gerser, who recently resigned.

J. F. Schumacher, who resigned as eastern manager of the Dollar Steamship Company on account of ill health, has been appointed assistant traffic manager of the Export Steamship Corporation.

James G. Tompkins, manager of the traffic department of the Emergency Fleet Corporation, at Savannah, Ga., has been transferred to Washington as assistant manager of the European and Mediterranean Trades division.

Edwin A. Gardner, formerly district passenger agent for the American Express Company at Seattle, has joined the staff of the Dollar Steamship Company, San Francisco, succeeding B. W. Guysi, resigned.

F. N. Melius, superintendent of the Hudson Division of the New York Central Railroad, with headquarters in New York, has been appointed assistant manager of the marine department.

Colonel F. W. Proffitt has resigned as assistant to President Palmer of the Fleet Corporation to enter a private business enterprise in Washington.

L. E. Havens has been appointed New York manager of the Strachan Shipping Company, succeeding Raymond D. Sullivan.

Murray McLean, who has been connected with the passenger department of the Admiral-Oriental Line for the past four years, was recently promoted to the position of commercial agent.

George C. Payne, formerly assistant manager of the Far East and Long Voyage Trades division of the Emergency Fleet Corporation, at New York, has been appointed manager of the traffic department at Savannah, Ga.

W. S. McPherson, Los Angeles agent for the American-Hawaiian Steamship Company, has been appointed general agent for the Atlantic Coast with headquarters at New York, and Fred A. Hooper, assistant traffic manager at the local office of the company, has been named to fill the position vacated by Mr. McPherson.

Paul H. Harwood, vice president of the Pan American Petroleum and Transport Company, has been elected second vice president of the American Steamship Owners' Association, and James Kennedy, superintendent of the marine department of the Gulf Refining Company, has been elected a member of the executive committee of the Association.

W. Neal Briceland, who for the past eight years has been connected with Robins Dry Dock and Repair Company, Morse Dry Dock and Repair Company, and the Lake Torpedo Boat Company, has accepted the position as sales engineer in the pump department of Root, Neal and Company of Buffalo, N. Y. Mr. Briceland is a graduate of Webb Institute of Naval Architecture. He also graduated from the U. S. N. Steam Engineering School of Stevens Institute and served as an ensign in the United States Navy.

M. M. O'Shaughnessey, city engineer of San Francisco, J. C. Stevens, consulting engineer of Portland, Ore., and Charles E. Staniford, consulting engineer of New York City, have been appointed members of a board to consider plans for extensive improvement on that part of the city of Portland bordering on the Willamette river. The plans include one mile of retaining wall along the river to take care of the high freshet conditions at which time the water reaches a height of 32 feet; important railroad terminal stations, warehouses, etc.

George Clark, manager of the Kensington Shipyard department of the William Cramp and Sons' Ship & Engine Building Company, Philadelphia, Pa., after 25 years of service has retired from his active connection in this capacity. At the time of a testimonial dinner given to Mr. Clark on the occasion of his twenty-fifth anniversary as manager of the yard, a complete account of his career as a shipbuilder was published in Marine Engineering and Shipping Age on page 563 of the September issue. He will be succeeded in his capacity as manager by Henry Fisher.

Stewart A. Johnson, president of the S. A. Johnson Engineering Company, Realty Building, Savannah, Ga., has been appointed agent for the Power Specialty Company and the Foster Marine Boiler Corporation for the entire South Atlantic district. This company also represents the Brunswick-Kroeschell Company, the O. Lee Cook Manufacturing Company, the Louisiana Oxygen Company, the Wager Furnace Bridge Wall Company, the Landmarine Corporation and the A. K. Miller Engineering Company. Mr. Johnson, who is one of the best known engineers in middle, south Atlantic and gulf ports, served his time at sea and with the Newport News Shipbuilding and Dry Dock Company as well as with the Pusey and Jones Company. In 1910 he joined the Skinner Shipbuilding and Dry Dock Company of Baltimore as assistant to the chief engineer. He left this organization in 1911 to go with the New York Shipbuilding Corporation as a marine engine draftsman and trial trip engineer. From 1916 to 1917 he was in charge of the steam engineering section, drafting department, for the Philadelphia Navy Yard; in 1918 and 1919 he was employed as chief engineer in connection with the construction of 9,400-ton ships for the Virginia Shipbuilding Company. On the completion of this contract in 1920 he joined the Emergency Fleet Corporation as a representative on the construction of ships for the Carolina Shipbuilding Company. From 1921 to 1923 he was local manager of the maintenance and repair department and manager of the operating department of the South Atlantic district of the United States Shipping Board with headquarters in Savannah, Ga. He was then appointed manager of the operating department of the Gulf district of the Board, resigning in March, 1924, to go into business for himself. Mr. Johnson holds a chief engineer's unlimited license for ocean vessels, and is a member of the Society of Naval Architects and Marine Engineers.

OBITUARY

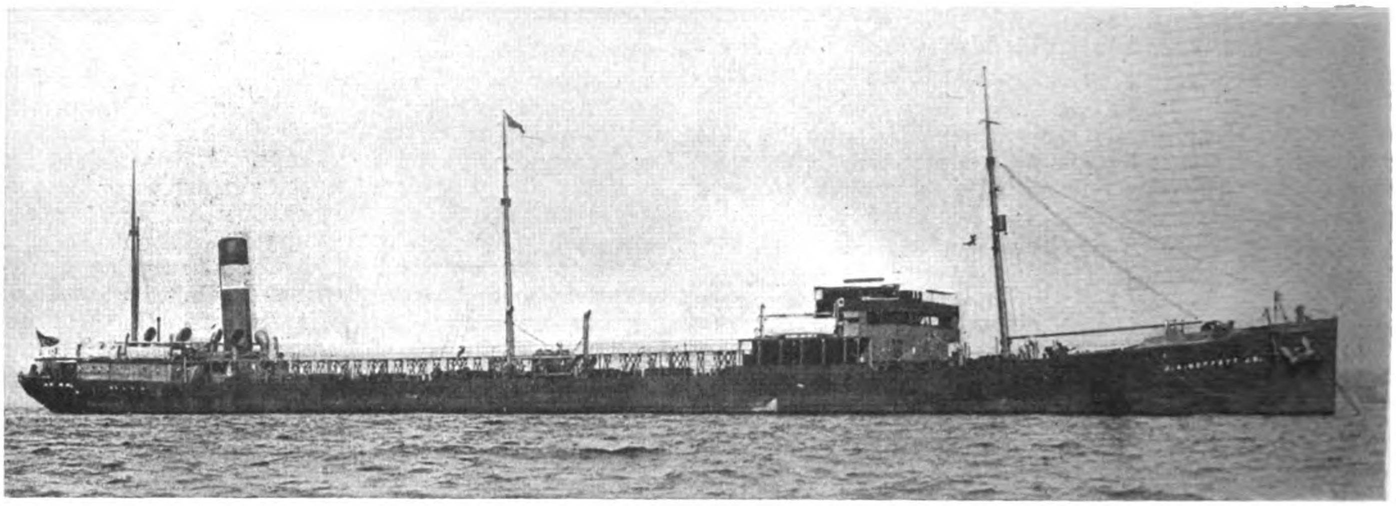
Otto Reuchlin, one of the founders of the Holland-America Line in 1873, died at his home in Rotterdam, Holland, November 17. He was a retired managing director of the Holland-America Line.

Daniel T. Hanlon, president of the Hanlon Drydock & Shipbuilding Company of Oakland, Cal., died at his home in Oakland following an attack of heart disease. He was 56 years of age.

George M. Andrews, who, for many years, was the general manager of the New York Shipbuilding Company's plant at Camden, N. J., died recently at his home in Haddonfield, N. J., after a long illness. Born in Dorchester, Mass., in 1864, Mr. Andrews was closely associated with machinery and engines practically all his life. His father was connected with the old Bridgewater (Mass.) Iron Works, where, in former years, many heavy forgings were turned out, among them the shafts of the great Sound steamers. He learned the machinist's trade in the old Fore River shop at Weymouth, Mass., later going to Bath, Me. After a considerable period at sea as an engineer, Mr. Andrews was, for a time, engaged in mining in Central America. In 1890, with the opening of the Pennsylvania Steel Company's new shipyard at Sparrow's Point, Md., he was made machine shop superintendent, remaining in this position until the yard was closed in 1895. A short period as superintendent of the Campbell & Zell plant in Baltimore, followed, after which Mr. Andrews came to Cramp's in Philadelphia, as machine shop superintendent, and there continued until he entered the employ of the New York Shipbuilding Company in 1901. With this company he remained until incapacitated by illness, about two years ago. Mr. Andrews had an unusual knowledge of machine shop practice and marine engines. The machinery of many of the largest warships of our Navy was built under his supervision. He had many friends, both in and out of the shipbuilding business, to whom his death means a very real and personal loss.

The Month's Shipping and Shipbuilding News in Brief

Shipyard, Steamship and Port Activities and Other Notes of Interest in All Branches of the Marine Industries



Tanker J. A. Moffett, Jr.—Type of S. O. Ship to be Converted from Steam to Diesel Engines.

Proposed Diesel Work

THE Alaska Railroad of Anchorage, Alaska, is considering the construction of a new boat for use on the Yukon River, and it is probable that propulsion will be by Diesel engines.

The propelling machinery of the steamer *Lawrence*, of the Port Huron & Sarnia Ferry Company, Port Huron, Mich., will be changed to Diesel engines, if present plans are carried out. The company recently rebuilt their steamer *City of Cheboygan*, doubling the vessel's capacity for automobile transportation.

Both of these Diesel installations are at present in the preliminary stage of development.

New Diesel Electric Fireboat Planned By City of Houston, Tex.

THE fire commissioners of the city of Houston, Texas, are planning the construction of a new combination fire and tugboat for the protection of the city's waterfront. It is learned from Commissioner Anderson that the proposed vessel, which is being designed by Cox & Stevens of New York, will have a length of about 126 feet, beam 27 feet and draft 9 feet.

The machinery installation will be Diesel-electric, power being supplied by two 500-horsepower Diesel engines. The boats will have a pumping capacity of 7,000 gallons per minute, against a 150-pound pressure. Plans and specifications will probably not be completed and submitted for bids for about two or three weeks.

Standard Oil Plans Dieselization of Two Big Tank Steamers, Proposals to Be Received at New York on December 15

PLANS and specifications for the conversion of one and two ships from steam to Diesel engines have been issued by the marine department of the Standard Oil Company of New Jersey, 26 Broadway, New York City. The vessels to be converted are of the type of the tanker *J. A. Moffett, Jr.*, which is of 9,564 gross tons.

The ships involved are twin screw vessels and if the contract is carried out, two 1,500-horsepower Diesel engines will be installed in each steamer. Bids are scheduled for receipt on December 15.

Bids to be Received This Month for Proposed Matson Liner Under Revised Plans and Specifications

REVISED plans and specifications for the construction of the passenger liner proposed for the Matson Navigation Company have been issued from the office of Gibbs Brothers, naval architects, No. 1 Broadway, New York. For the construction of the ship, under the original plans, the William Cramp & Sons Ship & Engine Building Company were low bidders, with a price of $4,792,000.

TURBO-ELECTRIC DRIVE

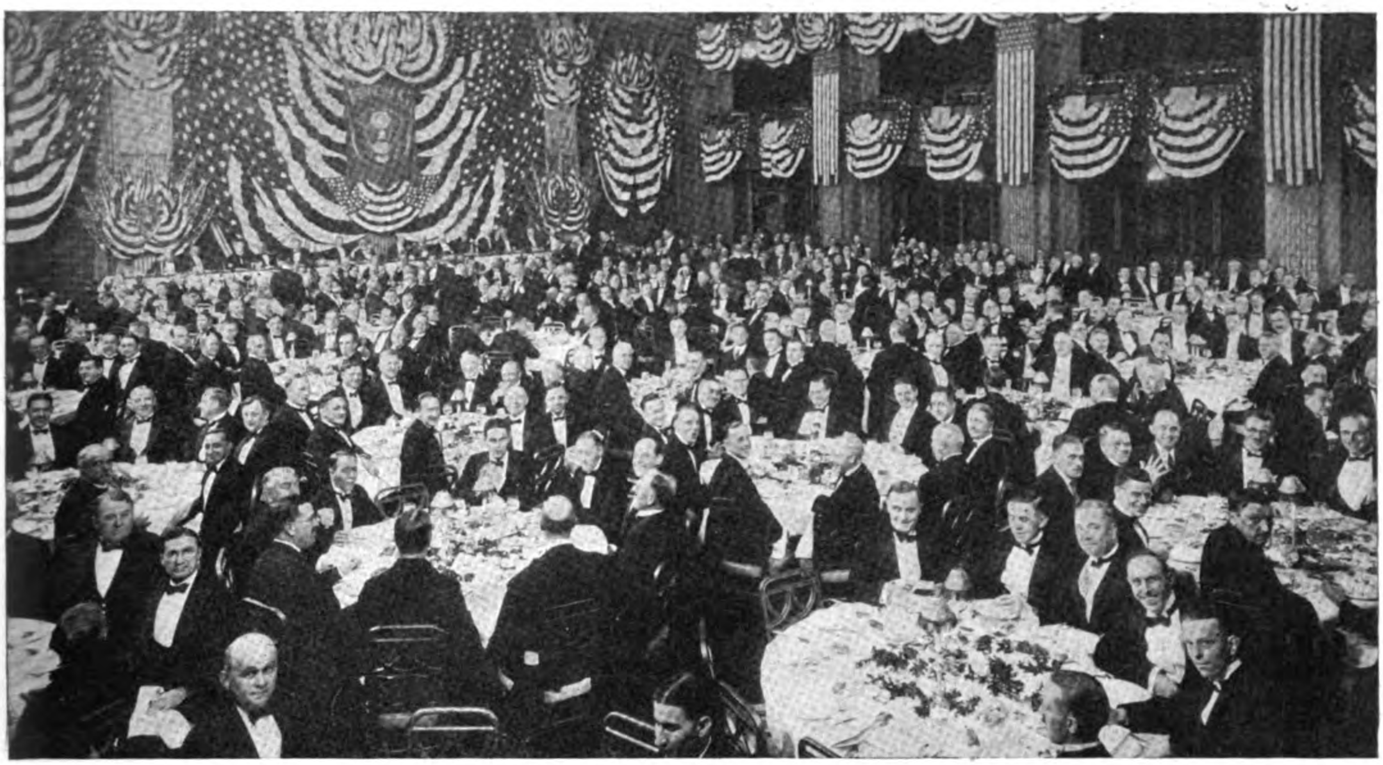
The new plans will provide for a number of changes which were made to meet government requirements, although it is understood that the other essentials such as propulsion, equipment, etc., will be carried out as originally intended. The ship will be turbo-electrically driven, the machinery being rated at about 24,000 horsepower. Electricity will be used throughout the ship for auxiliary purposes and the steamer will carry first-class passengers exclusively, accommodations being provided for a total of 500.

NEW BIDS TO BE ASKED

With the official announcement of the issuance of new plans and specifications it was stated that the bids would probably be received by December 5.

Shipyard Sold

Forty acres of land, including the main buildings of the old Terry Shipbuilding plant at Port Wentworth, eight miles west of Savannah, Ga., have been sold by the American Industrial Corporation to Elliott W. Reed, G. Leonard Allen, Harry Koplin and Frank M. Oliver. The purchasers will form a new organization to be known as the Savannah Steel Corporation, with a capitalization of $200,000 and the plant will be transformed into a rolling mill.



Annual Banquet of the Society of Naval Architects and Marine Engineers, Held in the Grand Ball Room of the Waldorf-Astoria Hotel, New York City, on November 14

$4,350,000 in Diesel Engine Contracts Divided Among Eight Manufacturers in Shipping Board Conversion Awards

THE first step toward modernizing a number of the war time fleet of merchant vessels was taken by the Shipping Board last month when it adopted a resolution formally authorizing the installation of internal combustion engines in eighteen of the Government's cargo ships. In taking this action the Board proceeded under authority conferred upon it by Congress on June 6, 1924, when a bill was passed empowering the Board to use for this purpose $25,000,000 of its construction loan fund.

It is felt by members of the Board that the modernization of the Government owned cargo vessels will, as it proceeds, make the fleet the equal of any merchant fleet in the world as respecting efficiency and economy of operation, speed and wide steaming radius.

With the $25,000,000 authorized by Congress for carrying out the Board's Dieselization program it is estimated that approximately fifty of the Government's cargo vessels will be converted. This will put the American merchant marine in the forefront in the shipping world and will give it the largest fleet of Dieselized vessels under one control. As fast as the vessels are converted they will take the place of the more expensively operated coal and oil burning vessels and will thus reduce to a great degree the cost of operating the entire Shipping Board fleet, and will increase the speed of delivery of American goods carried in American bottoms.

EIGHTEEN ENGINES ORDERED

The resolution passed by the Board authorized the purchase of eighteen Diesel engines, thirteen of which are approved type, single-acting Diesels as follows:

4—3,000 S.H.P. Busch-Sulzer Diesel Engine Co., St. Louis, Mo.
4—2,800 S.H.P. Cramps Ship & Engine Building Co., Philadelphia, Pa.
3—2,700 S.H.P. McIntosh & Seymour Corporation, Auburn, N. Y.
2—2,900 S.H.P. Pacific Diesel Engine Co., Oakland, Calif.

DOUBLE ACTING UNITS

For the purpose of developing a domestic Diesel industry and to secure such benefits of decreased costs, weights and space, as well as possibility of greater powers, which the double acting principle appears to offer, the Board has also authorized the purchase of the following double-acting engines:

1—2,700 S.H.P. McIntosh & Seymour Co., Auburn, N. Y.
1—3,000 S.H.P. Hooven, Owens, Rentschler, Hamilton, Ohio.
1—3,000 S.H.P. New London Ship & Engine Co., Groton, Conn.
2—2,900 S.H.P. Worthington Pump & Machinery Co., Buffalo, N. Y.

As will be seen, the awards are geographically well distributed among seven builders representing both Coasts, the Great Lakes and Middle Western States.

These eighteen units aggregate 51,650 shaft horsepower and an outlay of approximately $4,350,000, of which amount about $3,250,000, or 75 percent, represents the cost of the single-acting group. The double-acting type represents 22 percent of the total power and the relative average costs are $87.50 and $76 per horsepower, respectively.

While such prices will undoubtedly lead to a high total cost of conversion, it is well to note that they represent a substantial reduction from the original bids, and were arrived at by negotiations characterized by the fullest cooperation of the builders. Further material reductions are confidently expected on future orders through the experience that will be gained and development of the newer types which the Board has sought to encourage in its first award.

Wilson Line Plans Reconditioning of Day Passenger Steamer

PLANS and specifications are in course of preparation by George G. Sharp, naval architect and marine engineer, 30 Church Street, for the proposed reconditioning of the steamer *City of Chester* of the Wilson Line, Wilmington, Delaware, providing for the complete removal of present superstructure and main deck and the installation of new. The alterations in addition to the extension of the hull, provide for a complete new superstructure constructed on the "Seacraft" framing system.

The alterations will completely modernize the steamer and greatly increase the passenger carrying capacity. When completed she will have a length of 190 feet; molded beam at waterline, 34 feet; and depth 10 feet 6 inches. Among the innovations to be installed are dancing accommodations of unusual size and finish and terraced observation decks.

The work in general will consist of removing the existing superstructure deckhouses, along with guards and constructing an entirely new steel framing superstructure and over-hung guards, joiner decks and new main deck. The equipment to be installed will include new electric lighting; new plumbing and new communication systems; new life-saving and new fire fighting apparatus.

Proposals Received for Converting the S.S. Walter D. Munson from Cargo Carrier to Modern Passenger Steamer

PROPOSALS for the reconditioning of the steamship *Walter D. Munson* from a cargo carrier to a passenger ship were received by the Munson Steamship Line, New York, on Friday, November 14. No official announcement was made as to bids, although it is understood that the contract, if carried out, will involve the expenditure of over a half million dollars. Plans and specifications were prepared and issued by Theodore E. Ferris, naval architect, of 30 Church street.

Work to Be Done

The work in general provides for the alteration of the vessel from a cargo ship to a passenger ship, with accommodations for about 118 first class passengers in 52 rooms, made up of suites, and regular staterooms as shown on the plans, and there are also to be quarters for about 42 steerage passengers, together with crew accommodations, consisting of a total of about 90 in deck, engine and stewards department.

The accommodations for first class passengers, officers and crew will be accomplished by closing in a section of the ship aft from the present after end of the bridge, trunking No. 4 and No. 5 main cargo hatches and reducing the size of No. 5 hatch, raising main mast derrick table, booms and gear, raising winches and providing passenger rooms in the new 'tween deck space.

Deckhouse Changes

The present deckhouses on the bridge deck, including bridge and wireless house, are to be removed from the ship. The side hatches and side ports are to be closed up as are the fore and aft bridge bulkhead doors. The present engine room hatch is to be changed at the after end of the main stairway, the hatch narrowed up above the present bridge deck and extended to height to suit new conditions.

Two tiers of steel houses are to be erected on the present bridge deck for passenger and crew accommodations. Other changes will include the following:

Two tier steel houses erected on present poop deck for first class passenger accommodations; a wood wheel house with navigating bridge erected on new boat deck; a wood wireless house to be erected aft of wheel house; the new boat deck to be carried to side of ship and the boats carried on this deck.

The smoke stack is to be changed to suit the new condition, the after steam capstan is to be re-located and a new right and left steam steering gear with telemotor control is to be furnished and installed with steel inclosure at the after end of the upper deck. A calked wood deck is to be fitted fore and aft on the new shelter deck from the present fore end of the bridge to the after end of the ship. The new accommodations will be provided with a first class dining saloon, first class galley and pantry.

Lifeboat and Other Equipment

In addition to the present lifeboat equipment to be used, a new equipment of lifeboats with necessary additional davits is to be provided as follows: two boats aft, 24 feet by 7 feet by 3 feet, accommodating 30 persons each; five boats amidships, accommodating 37 persons each; and one motor lifeboat amidships, accommodating 28 persons.

A new steam heating system at a low ratio of heating surface is to be fitted in the ship. The present small ice machines are to be dispensed with and two new machines installed on the 'tween deck, each machine of four tons capacity and Brunswick make.

A separate estimate is required for supplying and installing complete two new Diesel heavy oil engine generating sets, electric operated windlass, electric operated steering gear, electric operated capstan, and electric operated winches. If this equipment is installed the present steam generating sets, steam windlass, steam steering gears, steam capstan and steam winches will be dispensed with entirely.

Great Lakes Plant Awarded Excursion Steamer Conversion

THE Detroit and Windsor Ferry Company has awarded a contract to the Great Lakes Engineering Works, of Detroit, for converting the day excursion steamer *Britannia* into an automobile and passenger ferry. The vessel is one of the newest and largest excursion steamers in the ferry company's fleet and has a capacity of 3,000 passengers. When rebuilt along the lines of the steamship *La Salle*, which plies between Detroit and Windsor and is considered one of the most successful automobile carriers in America, the *Britannia* will have almost an equal capacity. When placed in commission, about January 1, 1925, the *Britannia* will be able to transport 375 automobiles an hour.

Great Lakes Plant Gets Contract for New Wilson Transit Ship

A. W. THOMSON, president of the Wilson Transit Company, has closed a contract with the Great Lakes Engineering Works of Detroit for a steamer to be practically a duplicate of the steamer *James MacNaughton*. The vessel will be 605 feet overall, 580 feet keel, 60 feet beam and 32 feet deep. She will have a triple expansion engine and three Scotch boilers. It is estimated that the boat will cost close to $900,000.

Electric Boat Company to Build Submarines for Government of Peru

THE Electric Boat Company has closed a contract with the Government of Peru for two submarines, a quantity of torpedoes, and to construct a naval station or submarine base on the island of San Lorenzo, in the harbor of Callao. The submarines will be built at the Groton plant by the New London Ship and Engine Company, a subsidiary of the Electric Boat Company.

Charleston Drydock Co. Awarded Contract for Steel Snagboat

THE United States Engineer Office, Montgomery, Ala., has awarded a contract to the Charleston Drydock and Machinery Company, Charleston, S. C., for the construction and delivery of one 156-foot steel hull steam driven stern-wheel snagboat, at $189,900. The vessel is to have a length, molded, of 156 feet; length overall, 178 feet; breadth, molded, 33 feet; breadth overall, 34 feet 1½ inches; depth at side, molded, 5 feet 6 inches.

W. & A. Fletcher Co. Awarded Reconditioning of Steamship Ancon

THE contract for reconditioning the combination passenger and freight ship *Ancon* of the Panama Railroad Steamship Company, 24 State Street, New York City, has been awarded to the W. & A. Fletcher Company, Hoboken, as a result of bids taken on October 9, at which the Fletcher Company price was $482,400 and 116 days' time.

The specifications covering the contract include among other things, for the arrangement of the present spaces on the shelter bridge and boat decks to accommodate about 250 passengers and additional crew; installation of a new steel deckhouse; extension of the bridge deck; new boat deck; installation of refrigerator space and equipment, and a general overhauling of the main engines, boilers, auxiliaries and electrical system.

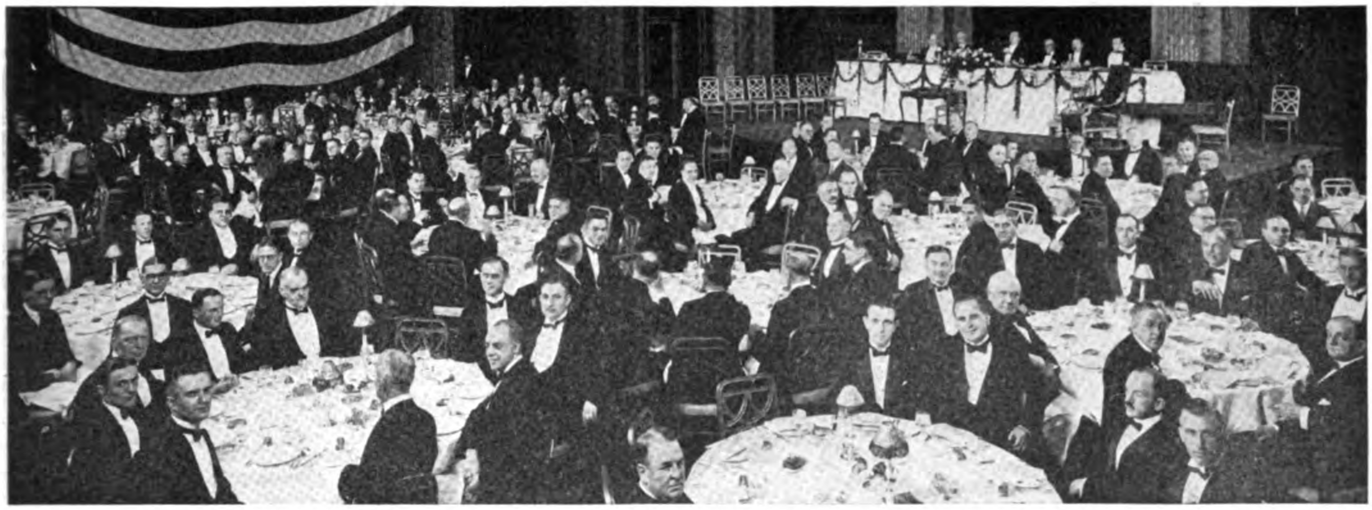
Sun Shipyard Awarded Repair Contract on Oil Tanker W. F. Burdell

WITH a bid of $20,800 and 14 days' time, the Sun Shipbuilding Company of Chester, Pa., was awarded the contract for general repairs to the tank ship *W. F. Burdell*, of the Pure Oil Company, following the receipt of proposals on Monday, November 3, at the office of Frank S. Martin, naval architect, 25 Broadway, New York City. The tenders submitted were as follows:

Sun	$20,800	14 days
New York Harbor	33,419	30 days
Newport News	33,470	23 days
Morse	36,000	25 days
Robins	38,750	18 days
Tietjen & Lang	39,841	20 days
Clinton	40,200	20 days
Shewan	43,986	25 days
Staten Island	47,150	25 days
Fletcher	47,500	28 days
Perth Amboy	52,000	28 days
Crane	75,640	45 days

Bids December 10 for Repairing Seagoing Hopper Dredge

Sealed proposals will be received by the United States Engineer Office, Norfolk, Va., until 12 o'clock noon, December 10, 1924, and then opened, for repairing the United States seagoing hopper dredge *Chinook*.



Fall Banquet of the American Marine Association at the Waldorf-Astoria Hotel, New York, on November 12

Marine Association Holds Annual Meeting and Banquet in N. Y.

At the annual meeting of the American Marine Association, held in New York, Wednesday, November 12, plans for the coming year were developed and the election of officers held. The election resulted in Col. E. A. Simmons, publisher of Marine Engineering and Shipping Age, succeeding F. J. Shipman as president of the Association and Capt. C. A. McAllister of the American Bureau of Shipping was chosen for the vice presidency. The following were elected to the executive committee: Capt. H. J. W. Fay of the Submarine Signal Corporation; F. J. Shipman, Texas Oil Company; S. W. Nevin, General Electric Company; Edward A. Colson of the Babcock & Wilcox Company and Charles A. Gleason of the Scovill Manufacturing Company.

Col. E. A. Simmons, President American Marine Association

The annual banquet of the Association was held at the Waldorf-Astoria on the evening of the 12th. The affair was marked by excellent speeches and several features of an entertaining nature. Winthrop L. Marvin in his address welcomed new men to the shipping industry and declared that the developments of the future must come through these men.

Rear Admiral Plunkett, commandant of the Brooklyn Navy Yard, made a forceful address to the members and their guests. He gave his views on the necessity for an adequate merchant marine as a naval auxiliary. He referred to the work done by President Harding at the time that the ship subsidy bill was being considered, declaring that the President struck the keynote of the situation when he said: "In view of the restricted naval construction it is well to have trained shipbuilding interests without which no nation can hold its place." In his history of the American merchant marine he described conditions of various periods from the days of the clipper ship to the present time. Every man who has anything to do with ships, or what goes into ships, must support any move designed to place the modern American merchant marine on a firm economic foundation.

During the course of the evening Capt. C. A. McAllister, vice president of the American Bureau of Shipping, presented the following resolution which was passed by acclamation: "Whereas the American Marine Congress now in session in the city of New York, this 12th day of November, 1924, under the auspices of the American Marine Association, and representing, as it does, all branches of American shipping and foreign trade, is fully aware of the adverse conditions confronting the maintenance and development of an American merchant marine in the foreign trade adequate to our needs, and having considered the many proposed forms of relief, has arrived at the conclusion that this vital essential to American economic success and aid to the national defense can best be helped by applying to it the underlying principle of the protective tariff, as now applied directly or indirectly to all other activities involving American labor and production; therefore be it

"Resolved, That the President of the United States be, and hereby is, respectfully requested, at the earliest possible time, to submit to Congress such recommendations, based on the principle indicated, as he may deem best to benefit and insure the permanent maintenance of a sufficient American merchant marine, under private ownership and initiative, to carry at least 50 percent of our sea-borne commerce in the foreign trade.

"Be it further Resolved, That the recommendations made at the last annual session of the American Marine Congress, relating to the encouragement of private ownership and operation of American vessels, are hereby reaffirmed, and that we now further recommend that there be formed an executive department of transportation, with Cabinet representation, to include in its functions all forms of marine, land and air transportation, as well as means of communication, such as telegraphy, telephone and radio, in so far as the Federal Government may have jurisdiction."

A special feature of the dinner was a travesty on shipping conditions in this country, "Heave Ho", written by Durward Primrose, managing editor of *The Marine Journal*, and staged by members of the association.

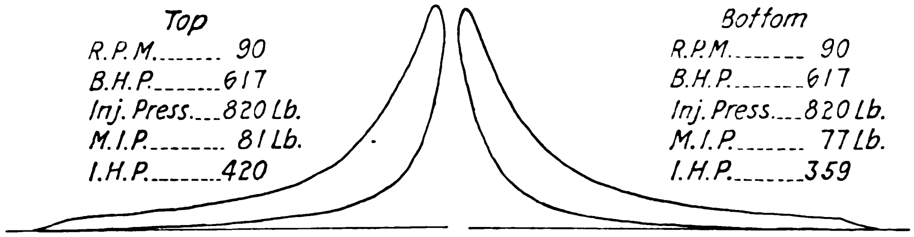
Capt. C. A. McAllister, Vice-President American Marine Association

Oil Sludge Removal Test

A new apparatus for the removal of oil sludge from ships' tanks was demonstrated at the yards of the New York Harbor Dry Dock Company, Staten Island, N. Y., on November 19 by the Oil Pumping and Reclaiming Company, Inc., 26 Water street, New York, when a barrel of sludge was emptied in 2½ minutes through 215 feet of transmission hose against a 50-foot head.

Worthington Engine Completes Thirty-Day Non-Stop Trial Run

THE 30-day, non-stop, full power trial of the new Worthington engine, carried out at the builders' works in Buffalo, N. Y., was successfully completed on the evening of October 25. The engine was allowed to stand over night without inspection or adjustments of any sort, and the next morning, in the presence of a large body of distinguished engineers representing the government and large private interests it was given an exhibition run during which it was run at full power, reversed and maneuvered in various ways. At the end of this run, it was immediately opened up and the guests given an opportunity of closely examining every detail, inside and out. As a matter of fact, some of the outside engineers were the first to inspect the interior of the cylinders and the piston and rod.



Typical Indicator Cards Taken During Test

The time which elapsed from the stopping of the engine to its complete opening for inspection, with the upper cylinder on the shop floor with its water jacket removed the piston and rod ready for gaging and the fuel valves disassembled, was 90 minutes.

The inspection which followed, and it was certainly a most thorough one, showed the engine to be in perfect condition, not the slightest indication of undue wear or deterioration being disclosed. Micrometer gaging of the liners and the moving parts revealed no wear, at any point, exceeding one-thousandth of an inch and, at most points, less than one ten-thousandth of an inch.

It was the general opinion, after a searching examination of the engine parts, that the test run could have been continued indefinitely.

The officially reported results of the 30-day run were as follows:

Duration of test	720 hours.
Total number of revolutions	3,879,921.
Average speed	89.8 R.P.M.
Average brake load	2,400 pounds.
Length of brake arm	15 feet.
Average B.H.P	615.
Average indicated M.E.P., top cylinder	81 pounds.
Average indicated M.E.P., bottom cylinder	77 pounds.
Average I.H.P	778.
Fuel oil consumption (average of four 2-hour tests) per B.H.P. hour	0.428 pound.
Gravity of fuel oil used	28 to 32° Baumé.
Fuel oil consumption per I.H.P. hour	0.339 pound.
Mechanical efficiency measured during the four tests	79.5 percent.
Average lubricating oil consumed in the cylinder and piston rod stuffing-box per 24 hours	4.03 gallons.
Average exhaust temperature	510° F.

The report, which was signed by Mr. Olson, the engineer representing the U. S. Shipping Board, who had been present throughout the test run, contains the following statements:

"The engine ran at a steady speed, without a single stop, during the entire period of the test. The exhaust, investigated close to the outlet from the cylinder, was at all times invisible.

"Readings of temperatures of cooling water, exhaust gases, cylinder liners, etc., and of pressures of scavenging air, injection air, oil pressure, etc., have been remarkably steady during the entire period of the test. The running of the engine is as smooth as that of a steam engine, and is marked by an entire absence of harmful vibrations.

"The test has, in our opinion, demonstrated the reliability of this type of engine as far as a thirty-day test could go, and has been entirely successful."

Officials of the Worthington Corporation said that the results of the test even exceeded their expectations, and that the unexpectedly perfect condition of bore, piston and piston rings would seem to indicate that the single walled, steel forged construction for cylinders and heads used for the first time in this engine has solved the most serious Diesel problem of the past, namely adequate heat removal and adequate resistance to heat stresses in the material.

The action of the builders in thus opening up their engine for outside, expert inspection without any previous or preliminary inspection of their own was a most unusual exhibition of confidence in the performance of a new and practically untried machine when submitted to a test of the most thorough and searching character. That this confidence has been justified is a matter of congratulation to the Worthington Company and of satisfaction to everyone interested in the advancement of American engineering attainment.

The whole conduct of the test and inspection has created a most favorable impression in engineering circles, an impression which gives promise of a wide adoption of the new engine for marine propulsion.

U. S. Chamber of Commerce Urges Marine Policy

Washington, D. C.

CHANGES in the administration and present policies of the merchant marine are urged by the United States Chamber of Commerce in a statement submitted to President Coolidge shortly after his reelection as representing the position of American business on important current national economic questions as indicated by the action of the organization's membership. Regarding the merchant marine the chamber said:

"The Chamber of Commerce of the United States does not feel that present policies and administration of the merchant marine are on a sound business basis calculated to promote the growth of an American merchant marine.

"It stands committed to policies of subsidy, mail subvention, private as against government ownership and operation and most strongly against government operation in competition with private operation which depresses private investment and initiative in this important field.

"It is unable to find, in existing law, warrant for policies of operating ships for purposes of competition or otherwise at a continuing deficit, while on the contrary it finds explicit statement of policies of transfer to private ownership as quickly as practicable, and for operation in the meantime only where there is profit or where continued operation holds out a fair prospect of future profit.

"To make possible the transfer of the government fleet to private ownership the chamber is convinced that the war cost of this fleet must be marked off and that its real value is not to be arrived at by original cost and application of depreciation, but by what the ships will bring in the market.

"It finds present policies undetermined and vacillating, making extremely difficult any dependence on American bottoms for shipping abroad because of uncertainty regarding the future plan of operation, and it believes that more definite authority in regard to policies and their maintenance than that now furnished by the Shipping Board as at present constituted with seven members would materially advance the situation which the present confusion of executive and regulatory functions hinders."

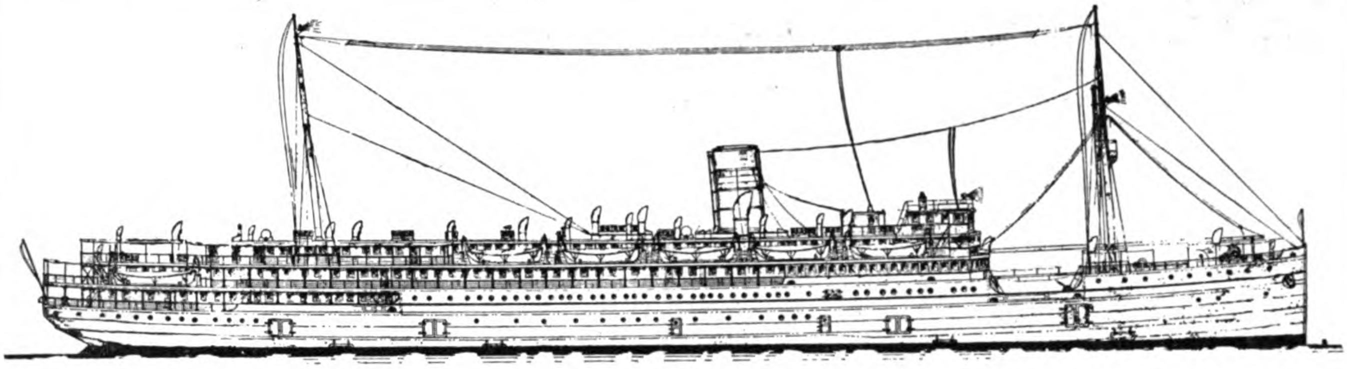
The chamber also believes that Congress should be asked to direct the United States Army engineers to make a comprehensive survey of the waterways of the country as a whole in their relation to other transportation agencies, and to recommend a definite plan and schedule of priorities for waterway development.

"This fact leads to the question why the waterways are not taking a proportionate share of the rapidly increasing traffic of the country," the statement continued. "It is because river improvement has been piecemeal instead of on a continuous and comprehensive plan. Congress has in the past from time to time called upon the corps of engineers of the United States Army for separate reports upon specified individual waterways. As a result of these reports and the action taken upon them, the country has many thousand miles of commercially navigable inland waterways. Congress has never yet, however, authorized a comprehensive survey and report upon the waterways of the country as a whole with a plan and order of priority for the development of the several waterways as parts of the national transportation system."

Sullivan Low Bidder For Two Steel Tugs at N. Y. Central Opening

THE J. W. SULLIVAN COMPANY, with a price of $249,750 submitted the low bid for the construction of two steel, steam driven tugboats for the New York Central Railroad Company at the opening of tenders at noon on November 14. No announcement was made regarding award of contract although it was intimated that if these bids are rejected, new specifications may be issued later providing for two tugs with Diesel electric machinery. The prices submitted yesterday were as follows:

J. W. Sullivan	$249,750
Bethlehem	259,900
New York Ship.	265,000
Newport News	275,000
Staten Island	285,900
Todd Shipbuilding	292,370
W. & A. Fletcher	308,000
Federal	308,880
Sun	355,270



Porto Rico Line Steamer

OUTBOARD profile of passenger and freight ship to be built by the Newport News Shipbuilding & Drydock Company for the New York & Porto Rico Steamship Company. The vessel will have a length over all of 429 feet; length between perpendiculars, 412 feet; breadth, molded, 59 feet 6 inches; depth, molded to hurricane deck, 35 feet; depth, molded to main deck, 26 feet 9 inches; designed load draft, 23 feet 6 inches; speed in service, 16 knots. The ship was designed by Theodore E. Ferris, naval architect and marine engineer, of 30 Church Street, New York, and will cost close to two and one-quarter million dollars. It is expected that the ship will be completed the latter part of next summer. Propulsion will be by turbine engines.

Tanker Construction Job Awarded Moore Dry Dock Company

A CONTRACT for the construction of a tanker to be used in the bay service of the Union Oil Company is reported as awarded to the Moore Drydock Company. The vessel is to be a twin screw Diesel-driven tanker and will have a capacity sufficient for all purposes for which it is being built. The proposals received were as follows:

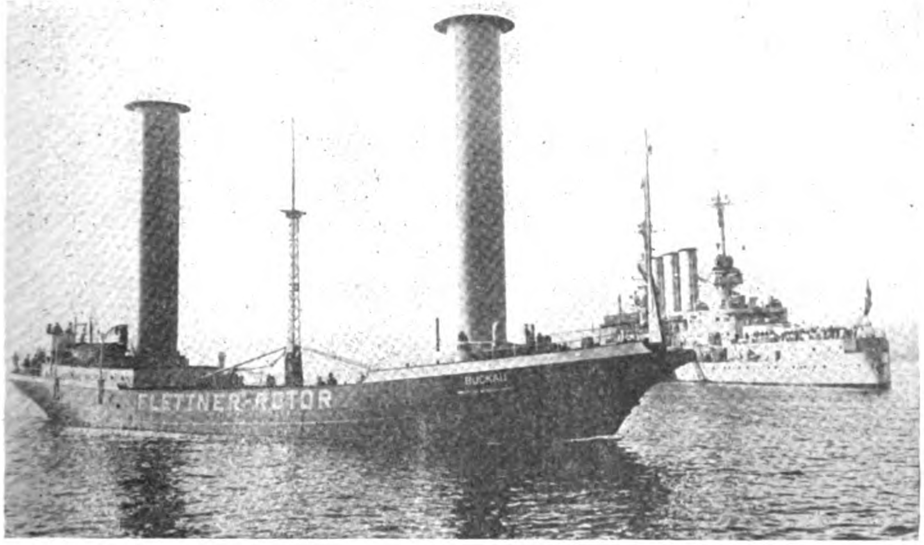
		Days
Moore Drydock Co.	$145,998	125
Bethlehem Shipbuilding Corp.	174,979	135
Los Angeles Shipbuilding Co.	175,000	120
General Eng. & Drydock Co.	180,000	150
Pacific Coast Eng. Co.	194,749	180

Diesel Engine Contract

A directly reversible 400-horsepower marine oil engine to be installed in a tug for the Jersey City Stock Yards Company is being built by the Ingersoll-Rand Company. The hull for this boat is being built by the Crowninshield Shipbuilding Company, Fall River, Mass. When completed the tug will operate on the Hudson River between the Jersey City Stock Yards and various points in New York Harbor.

Barge Contract Placed

A contract for the construction and delivery of two steel barges has been awarded by the United States Engineer Office, War Department, Washington, D. C., to the Newport News Shipbuilding and Drydock Company, at a price of about $12,500. The vessels are to have a length, molded, 60 feet; beam, molded, 22 feet; depth, molded, 4 feet.



P. & A. Photo.

Flettner Wind-Driven Rotor Ship Buckau in Hamburg Harbor

TRADE PUBLICATIONS

Portable Grinders.—A mailing folder, describing the Du-All grinder for use in machine shops, is being sent to the industry by the Gisholt Machine Company, Madison, Wis.

How to Pile.—The Revolvator Company, Jersey City, N. J., manufacturers of tiering machinery, lift trucks, portable elevators, and the like, in a bulletin recently published shows how these machines may be adapted to the handling of a great variety of packaged, cased, rolled and baled goods.

Heat Treating.—A bulletin entitled "The Melting Pot," published by the Chicago Flexible Shaft Company, Chicago, Ill., contains articles on heat treating, pyrometers, gas combustion, tempering, annealing and other heat treating problems in the solution of which Stewart furnaces of various types may be found useful.

Diesel Governors.—The Ramsay Diesel governor, manufactured by Charles Cory & Son, Inc., New York, is described in a pamphlet distributed by this company which has been reprinted from *Motorship*. It is stated that this governor has proven successful in preventing propeller racing, shaft breakage and damage to marine Diesel engines.

Lubrication.—We are in receipt of two interesting catalogs, from Sterns, Ltd., of London, describing their special lubricating oils for turbines and internal combustion engines. This firm has made a special study of the various conditions to be met in the successful lubrication of power generating machinery and the catalogs contain much interesting information along this line of engineering.

Disc Bearings.—The Nordiska Kullager Aktiebolaget, Gothenburg, Germany, manufacturers of disc bearings with self-guiding rollers, represented in this country by the Wollmar Engineering Corporation, New York, has published a catalog describing the theory and application of a new type bearing known as the NKA bearing. A special section of the catalog is devoted to the installation of marine thrust bearings.

Strip Chart Recorder.—A pamphlet illustrating and describing a newly designed recorder of the strip or continuous chart type, intended for use where it is desirable to obtain a record of temperatures or pressures for an extended period of time and where the cycle of operation is of relatively short duration, has been sent out by the American Schaeffer and Budenberg Corporation, Brooklyn, N. Y. The Columbia strip chart recorder, as it is known, is available for the recording of all pressures (steam, air, water, ammonia, hydraulic, etc.), vacuum or temperatures up to 1,000 degrees F.

U-Tube Storage Heater.—The new bulletin on Russell U-tube storage heaters which has just been published by The Griscom-Russell Company, New York, has several features that make it of real usefulness and permanent value of architects and heating engineers. One of the features that will be of particular help in selecting a suitable heater for given conditions is the completeness, logical arrangement and legibility of the tables which cover an exceptionally large number of steam pressures as well as initial and final water temperatures, and include complete details of tank sizes, capacities and dimensions for a wide range of storage capacities. Typical examples of heater and tank selection are fully worked out for various operating requirements to show the factors that must be taken into consideration to assure satisfactory results. Besides a complete description with details of construction and specifications of the Russell U-tube storage heater, the bulletin also contains a valuable table of data which has not hitherto been published on hot water requirements for various industrial and domestic uses and applications.

De Laval Velocity Stage Steam Turbine.—An improved steam turbine, specially designed for use with high pressure, high temperature steam, is described in a publication just issued by the De Laval Steam Turbine Co., Trenton, N. J. The turbine is of the impulse velocity stage type, so that the wheel case contains steam at exhaust pressure and temperature only. The steam inlet nozzle, governor valve bodies and steam chest are combined in the casing cover casting, thus not only reducing the area of high temperature radiating surfaces and eliminating joints subject to high pressure, but also keeping the high temperature steam away from the bearings, which do not require water cooling. The turbine casing is supported on a single pedestal at a point close to the center line of the shaft, so that temperature changes will not cause misalinement. The speed of the turbine is controlled by a governor mounted on the turbine shaft, the transmission levers being above the shaft in a readily accessible position, and the speed can easily be adjusted while the turbine is in operation. On the opposite side of the wheel is an emergency overspeed trip, which operates an entirely separate valve and which is so arranged that it can be tripped and reset by hand while the turbine is running. For speeds above 3,600 revolutions per minute, the turbine is supplied with a vertical shaft governor driven from the turbine shaft through a worm and worm wheel, and with an oil pump for forced feed lubrication. This line of turbines is built in capacities from 1 to 800 horsepower and is designed primarily for non-condensing service, as in driving high and moderate speed machinery, such as small direct current generators, alternators, centrifugal boiler feed pumps, circulating pumps, blowers and compressors and similar machinery.

BUSINESS NOTES

The Diamond Power Specialty Corporation, Detroit, Mich., manufacturers of the Diamond valve-in-head soot blower, will have an exhibit in Booth 17, at the Mechanical Engineering Power Show, Grand Central Palace, New York City, December 1 to 6, 1924. Messrs. I. S. Forde, Detroit home office, assistant sales manager, C. R. Vincent and H. W. Gilson, New York representative, M. J. Miller, Philadelphia representative, and Robert June of Detroit, will be in attendance at the booth.

Charles Cory & Son, Inc., has called attention to the fact that a number of items of Cory equipment have been included on the steamship *District of Columbia* recently launched at the Pusey and Jones Company yard, Wilmington, Del. This ship has been built for service between Norfolk, Va., and Washington, D. C. The Cory part of the installation includes running lights, switchboards, decorative fixtures, steam pipe fixtures, mechanical telegraphs, navigation bells, general alarm systems, call bells, Cory electro-pneumatic fire alarm and voice tubes.

An innovation in showing full sized underfeed stokers in operation will be an outstanding feature of the exhibit of the Detroit Stoker Co., Detroit, Mich., manufacturers of Detroit single and multiple retort underfeed and V-type stokers. This exhibit will be held in Booths 205, 206 and 207 at the Mechanical Engineering Power Show, Grand Central Palace, New York City, December 1 to 6, 1924. Messrs. F. R. Strale, Detroit home office, R. L. Beers, chief engineer, N. G. Phelps, New York office, and J. M. Keylor, Philadelphia office, will be in attendance at the booths.

In addition to the equipment and material which entered into the construction and fittings of the steamships *Greater Detroit* and *Greater Buffalo,* which were described on page 643 of the November issue of Marine Engineering and Shipping Age, the Pantasote Company, New York, supplied 80,000 feet of Vehisote for use in these ships. Included in the boiler room equipment of these vessels are two types of valves supplied by the Scott Valve Manufacturing Company of Detroit. These are Scott pop safety valves and the Flower type cushion check valve; the latter is made to handle pressures up to 250 pounds.

The Maxim Silencer Company, Hartford, Conn., reports the following recent installations of Maxim silencers: One 12-inch size cast iron silencer on the exhaust of the 1,150-horsepower McIntosh & Seymour engine in the new dredge *Diesel* of the United Dredging Company, Galveston, Texas; one 5-inch size and one 8-inch size cast iron silencer on the exhaust of the 135-horsepower and 375-horsepower Lombard engines installed in tugs owned by the Long Island Machine and Marine Construction Company; two 8-inch size cast iron silencers for the new Standard Oil Company tanker on the exhausts of two 400-horsepower Pacific-Werkspoor engines; one 8-inch cast iron silencer on the exhaust of a Fairbanks-Morse marine engine operated in regular service by the Texas Company of New York.

Marine Societies

America

American Marine Association. 15 Park Row, New York. President—Frank J. Shipman.

American Society of Marine Designers. Secretary—B. G. Barnes, 202 Kendrick Ave., Quincy, Mass.

American Society of Naval Engineers. Navy Department, Washington, D. C. Secretary-Treasurer—Commander Bryson Bruce, U. S. N., Bureau of Engineering, Navy Department, Washington, D. C.

American Steamship Owners' Association. 11 Broadway, New York. President—Alfred Gilbert Smith. Vice-President and General Manager—Winthrop L. Marvin.

Atlantic Coast Shipbuilders' Association. 1600 Walnut Street, Philadelphia, Pa. Secretary—C. S. King.

Council of American Shipbuilders, Inc. 30 Church St., New York. President—Homer L. Ferguson. Secretary-Treasurer—Henry C. Hunter.

Lake Carriers' Association. President—Wm. Livingstone, Dime Bank Building, Detroit, Mich. Secretary—George A. Marr, Rockefeller Building, Cleveland, O.

National Association of Engine and Boat Manufacturers. 29 West 39th Street, New York City. Secretary—R. R. A. Hand.

National Association of Masters, Mates and Pilots. National Secretary—M. D. Tenniswood, 308 Vine St., Camden, N. J.

National Marine Engineers' Beneficial Association. Headquarters, 311-315 Machinists Building. Washington, D. C. Secretary-Treasurer—George A. Grubb.

National Merchant Marine Association. Munsey Bldg., Washington, D. C. President—Hon. J. E. Ransdell.

Neptune Association. 21 Pearl St., New York City. Secretary-Treasurer—Captain John F. Milliken.

Ocean Association of Marine Engineers. 15 Whitehall St., New York. Secretary—Bert L. Todd.

Port of New York Authority. 11 Broadway, New York. Chairman—E. H. Outerbridge. Secretary—William Leary.

Society of Naval Architects and Marine Engineers. 29 West 39th Street, New York. Secretary and Treasurer—Daniel H. Cox.

The Maritime Association of the Port of New York. 78 Broad St., New York City. President—Charles H. Potter. Secretary—Walter F. Firth.

The New York Tow Boat Exchange. 11 Moore St., New York. Secretary—Irving G. Keller.

United States Naval Institute. Naval Academy, Annapolis, Md. Secretary and Treasurer—Commander H. K. Hewitt, U. S. N.

United States Ship Operators' Association. 149 Broadway, New York. President—C. H. Potter.

Canada

Grand Council N. A. of M. E. of Canada. Grand Secretary-Treasurer—Neil J. Morrison, Box 886, St. John, N. B.

Great Britain

Institute of Marine Engineers, Incorporated. 85/88 The Minories, London, E.1.

Institution of Engineers and Shipbuilders in Scotland. 39 Elmbank Crescent, Glasgow.

Institution of Naval Architects. Adelphi Terrace, London, W. C.

Northeast Coast Institution of Engineers and Shipbuilders. Bolbec Hall, Westgate Road, Newcastle-on-Tyne.

Italy

Collegio Degli Ingegneri Naval e Meccanici in Italia.